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# United States Naval Institute Proceedings

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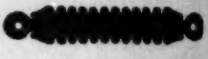
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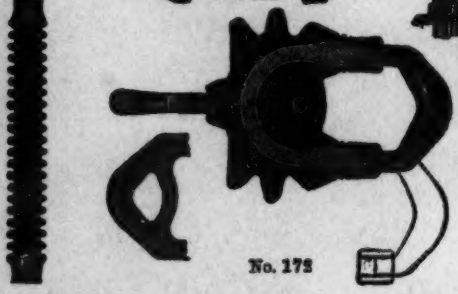
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# UNITED STATES NAVAL INSTITUTE PROCEEDINGS

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

## THE BATTLESHIP

By COMMANDER E. F. EGGERT, C. C., U. S. Navy

Military power, whether afloat or ashore, has in all ages been measured in units of skilled fighting men, properly equipped. Improved equipment increased the value of the unit, as is instanced by the success of the armored Greek, when opposed to the unarmored Asiatic.

Equipment was more or less permanent, could be captured, or passed on to new men; the men were but mortal; and, on the average, lack of men set limits to the power of the state.

From this fact arose the effort to increase, by constant improvement, in the equipment, the effectiveness of the fighting man at the front, and, as civilization developed, and the mechanical arts with it, the value of the unit of power was constantly augmented.

Equipment grew in effectiveness, and also in cost. In the Middle Ages equipment became so expensive that only a small part of the fighting men could be fitted out with the best equipment. Cost is a question of labor used in production, and a certain part of the man-power is required to furnish this labor.

Economy in money requires that we obtain as good equipment as is possible with the money available, for the numbers of fighting men we can count on. It must be here remembered that money means labor, and labor means time. It would be a simple matter to improve the equipment of the fleet, if there were no question of cost. No objection could be found to a complete

replacement of the battleship force by new ships of much greater size and power, if there were no loss of time, and no increase in the cost of maintenance. It is not necessary to argue that the men now on the old ships would have much greater fighting power on the new ships. But the millennium has not yet come, and there is the ever present spectre of cost.

When all is said and done, there is available a certain amount of money, to be expended in a given time, for fighting ships. Leaving out of consideration the small craft and auxiliaries, which consume but a small fraction of the total, the available funds will build, in a given time, a number of capital ships, the number depending on the type. What type shall be built? Clearly, the type or types that will give their crews, of a fixed number, the greatest fighting power. And why build capital ships? For the reason that the capital ships do give to a fixed number of men the greatest fighting power. Fighting power means offence *and* defence. It is just as necessary to protect our own men and material, as it is to damage or destroy the enemy's men and material.

The battleship has been developed into a machine that represents the greatest amount of fighting power that can be obtained from its crew. There is both offence and defence, balanced evenly. At different periods we will see battleships of different sizes, and different degrees of effectiveness, depending on the state of mechanical development at the time. But always there is the balance between offence and defence. A ship is no more a battleship, if she has no armor, than if she has no guns; if she has no torpedo protection than if she has no offence against torpedo vessels. The battleship has consistently represented the maximum fighting power for a given crew, which is the only thing that counts on the day of battle.

Many times have we seen special types evolved, even in capital ships. They have been brought about in most cases, perhaps in all, by ideas that might be traced to other bases than the fundamental one of fighting, and of producing fighting equipment. Already we have seen many of them disappear, after a short life, while the battleship type so far has remained. We need only mention the ram, the commerce destroying cruiser, the armored cruiser, the monitor. They all have wasted money that should have gone into fighting ships. We now have the battle cruiser,

that has grown until it is twice as expensive as a battleship of its date. Has it adequate fighting power against capital ships? There is but a limited offence and practically no defence. We shall perhaps see the battle cruiser go the way of the others.

We cannot tell who will be our enemies of the future. It takes a long time to build a fighting fleet, much longer than it takes to start a war. As long as we cannot predict whom we shall have to fight, and what forces we must have, we can only prepare on the basis of our own ultimate strength. We can tell how many skilled fighters we can obtain for the navy, and how many others must be reserved for the army. The number is large, the cost of equipment is large, and we cannot afford to waste any labor in building it—waste it on material that will not give our men an adequate amount of fighting power for the cost represented. That should always be the criterion. Do we get a proper return in fighting power for the expenditure?

What is fighting power in a battleship? First, it is represented by the destruction the ship can accomplish. Secondly, it is the defence it affords, from destruction, to its own crew. We must consider these separately.

The first, the offence, is nowadays easily measured. We no longer expect to lay alongside and board, or to ram, or perhaps even to torpedo, in a capital ship action. The power of offence in a battleship is measured by the number of effective hits she can make with her main battery, before her allowance of ammunition is expended. It is useless to make hits that glance off armor or decks, that make small holes in light upper works, or that do minor damage about the decks. It is only when serious damage is being done that the fighting power of the enemy is being crippled. Also, it is useless to rain projectiles about his ships, without hitting.

Let us now consider the defence. This has perhaps shown up better in the battles of the present war than has the offence. Battleships have been torpedoed in battle, and have remained in line. Ships have been exposed to heavy fire, such as, before the war, would have been considered fatal, and they have been heavily hit, but they went on fighting. But still, some of the ships, after receiving a few hits, were out of control, and some ships barely reached port. There is still much to be desired in the defence. There should be no lucky shots, a ship should

withstand severe pounding and still remain a fighting ship; she should be able to receive several torpedoes and not only remain afloat, but an effective fighting ship, with speed and control undiminished, and offensive power intact. Do we say that this is impossible? It is not. It can be done, if we give to protection its proper place. It may be that in Farragut's time the best defence was a vigorous offence, but times have changed; main batteries at short range are now entirely too vigorous for an undefended ship to withstand.

These two, offence and defence, are the main requirements in a capital ship. We have gotten into the habit of expecting a certain fixed amount of them in every battleship, depending on its size; in other words, these two have been given a fairly standard percentage of the total displacement, and it has not been a small one either. Perhaps this has been a bad habit, but there you are, and, after all, a habit is always the result of subconscious justification, if nothing more. We can often justify an action to ourselves, even without logic. If it withstands the test of time, it is usually right.

Providing as large an amount of offence and defence as possible in each ship ensures fighting efficiency and economy of expenditure. These two, offence and defence, should be as large as it is possible to make them, and other factors should be of secondary importance, and receive corresponding attention and weight. Not to do so means that we distrust our premises and neglect what should be considered an axiom, namely, that fighting power consists of but two things, as we have said, offence and defence.

Chief of the secondary factors that go to make up the battleship, leaving out of consideration the hull that carries all, is mobility. A battleship must of course be brought to the scene of action, and within striking distance of the enemy. When she has arrived at the distance she chooses, she must maintain her position so as to fight her battery to the best advantage, and she should be able to take advantage of the changing conditions of the battle. To do all this she must have power of motion and of controlling her motion. We need not here discuss the question of manœuvering ability, since this does not cost much, and is not so important as it was in the days when the ship herself was intended to be the weapon.

Mobility requires a certain maximum speed and also ability to travel a considerable distance, while hunting the enemy. The first requires a certain expenditure, irrespective of the second, and both together, if insisted on in exaggerated amount, mean a very heavy expenditure, to the detriment of fighting power. We should therefore inquire carefully whether they are needed in great amount.

We can perhaps arrive at an answer better by inquiring how much mobility we can afford to give the battleship. It might be said at once that the battleship will not be required to chase small craft, nor fast cruisers, not even the ships of the battle-cruiser type. We recognize readily that this is beyond the capacity of the type. What then is she required to chase? There is no other type except her own type. If it should be required that she chase other battleships, then this can be done only in the case of older ships of the type, for, if the higher speed type is approved and copied by other nations, then the difference of speed that makes overtaking possible disappears, and if the type is not approved, the enemy will have instead a type of greater fighting power, for the same expenditure, and it would not be safe to engage in pursuit of such an enemy. There are therefore limitations in the uses of high speed in a battleship.

The question of how much mobility we can afford to give the battleship type depends on what we lose in fighting power when we substitute extreme mobility. There was a time when we were satisfied with fifteen knots in a battleship, as a maximum speed, but we will find that the weight or cost given to the motive power at the time was about the same as we would now give to a modern ship with a higher speed. In other words, maximum speed grows with time, just as size and other qualities do. It is therefore not an absolute figure, but a relative one. It is when we attempt to determine what we gain or lose in fighting power by decreasing or increasing the motive power, that we can arrive at a fairly satisfactory determination of what cost we can afford to stand for motive power.

It has been customary in our usual standard battleship to give about 40 per cent of the displacement to fighting power, represented by armament, armor, and ammunition, and 15 per cent to motive power, the hull making up the remainder. The hull always includes a considerable amount of weight that is strictly

protection, such as the armored decks, and torpedo protection, so that the percentage given to fighting power is really considerably greater than the figures show. If now we take away some of the displacement used for motive power, what can we do with it? Evidently not much, since we could not take very much after all. The ship must have some motive power, and common sense will indicate without any figures at all that we could certainly not take away more than, say, half. Seven per cent of the total added to the forty or more already given to fighting power would not make any startling changes in the power of the battery, the thickness of the armor, or the amount of ammunition, especially as we would want to increase all of these factors at the same time. The loss in motive power represented by the seven per cent would reduce the radius of action to half, and the maximum speed from 21 to somewhere around 16 knots. It does not need any elaborate argument to show that the fighting power does not lose much if we retain the present speed and radius of action, and that there is therefore nothing to be gained by reducing these. The question now becomes, What do we lose when we attempt to increase radically the cost of motive power?

It might here be mentioned, though it should not be necessary, that minor changes from one design to the next, in the quantities referred to, are of no importance, provided they are not progressive. There is no absolute limit in either of the conflicting factors, and one or two per cent one way or the other need not be considered.

We must not, furthermore, take into account large quantities of fuel taken on board for a long voyage, which greatly increase the draft. It is never intended that these should be on board at the time of action, and it is only the weight on board in fighting trim that need be considered. We are not now concerned with any ill effects such extra weights might have on the habitability or seaworthiness of the vessel.

If, now, we should double the allowance given to motive power, we see that the effect on fighting power, if we retain the same total cost, is as great as the effect on the motive power was in the previous instance. The allowance is cut from 40 per cent to 25 per cent, and the effect on each of the quantities included in the general term, fighting power, is serious. We would have

left only about 60 per cent of the previous quantities; thus, the armor would have to be reduced from thirteen to eight inches in thickness, the battery from twelve guns to eight, and the other factors in proportion. Clearly, the effect is not a happy one from the point of view of fighting power. To offset this, we have only increased the maximum speed from 21 to 23 knots, and added a little to the radius of action, hardly a compensating advantage.

In our latest battleships we have increased the speed from 21 to 23 knots. If we had retained the size previously standard, the above would have represented the result. It has been necessary to increase the size and cost of the vessel to obtain this increased speed. Of course there were other increases made, principally in the battery power, but we paid for the increased speed just the same. The size of the vessel was increased over thirty per cent, or by an amount equivalent to nearly the whole of the fighting power of the previous smaller vessel. That the number of guns in the main battery was increased fifty per cent does not imply that the fighting power has been correspondingly increased. The size of the target has been increased, or in other words the ability, and therefore the certainty, of the enemy to increase the number of his effective hits; the efficiency of the three-gun turrets is probably less at medium ranges, from the ballistic standpoint; and we might question whether after all the fighting power has been much increased.

It is to be expected that the size of battleships will increase and continue to increase, and we might expect with each increase of size a small increase of speed, and perhaps of normal radius, but it is natural to assume that the country will expect also a corresponding increase in the fighting power of the larger craft. There is no future limit to the size of the type, nor to the ultimate speed that will be attained, but the country must pay for the total navy finally built, and has a right to expect proper fighting efficiency.

If the above has been the effect of doubling the cost of the motive power, what shall we say of the latest proposition, the so-called fast battleship? Here we have motive power comparable to that of our proposed battle-cruisers, and fighting power distinctly inferior to that of the last class of battleships, the 21-knot ships. The displacement is nearly doubled, and the cost,

if the vessel is ever built, will be more than doubled. The result must necessarily be that in the long run, in a given term of years, the fighting power of the entire fleet must suffer. And what would we gain by it? Merely that these vessels, in some circumstances, might run at a higher speed than the rest of the fleet. The offensive power is not greater than that of contemporaries of slower speed, it is measured by the allowance of ammunition, and the use that is made of it. Would this vessel, if she dashes here and there at high speed, making a few hits here and a few there, do a greater sum total of damage than if she settled down to fight an opponent in the old-fashioned way? After all, we are not concerned with an indecisive battle, where there is a little damage done, and a ship sunk here and there. We must consider a battle that will settle, once for all, for that war, the mastery of the seas. For the money that we spend on these vessels, the enemy can put more than twice the fighting power afloat, and where then is our mastery of the seas?

Neither can we consider the possibility of shaking the enemy's morale, by concentrating fast ships on detached portions of his line and destroying them. In the first place, we must expect to meet an enemy as determined as ourselves, and not to be shaken by small losses. In the second place, we can expect him to be equally skillful, and not to leave a few units unsupported. Again, concentration can be of value only at short range, for at long range small differences of distance disappear, and concentration of fire on one ship means that other ships will not get the proper amount of attention. Can we imagine these vessels, lightly armored, and immense targets, coming to close quarters with standard battleships?

In all this discussion, we deal with equal forces on both sides. If we were greatly superior to our opponent, the exact type of ship would be unimportant. If we were much inferior, we would have no chance anyway. The assumption of equal forces appears reasonable. Even if we were slightly superior, we could not give hostages to fortune by wasting fighting power.

If the high speed battleship does not seem a reasonable proposition in a general battle, then why the high speed? As we have said before, we would not expect a battleship to chase small craft. We do not use a sledge hammer to smash a fly. It is too slow, and takes too much effort. We get a swatter, a light, quick, cheap

weapon. If the small craft are going to bother us, we can make plenty of swatters, of the requisite kind, out of the fifty millions one of these fast battleships will cost.

It might be said that we need high speed to overhaul the enemy and bring him to action. But we do not build these ships over night. It is a long, painful process, and meanwhile our prospective enemy can build the same kind. Can we ever steal a march on our possible enemies, and build vessels that cannot be copied in sufficient numbers before ours are ready? That has not, with us, been the case in the past, and it will not be in the future. It has not been so with others, except where they had a great building capacity, which means, of course, great available man power.

Again, if we have the superior fighting fleet, but inferior speed, it might be said that the enemy can harry our coasts, and do much damage, before he is brought to action. That has been said many times, and as often it has been answered that such action has no military value, and will not decide the war. There never yet was a case of an inferior, though faster, fleet avoiding contact with the superior fleet. In the end there was either battle or blockade, and one is as effective as the other.

Exceptionally high speed in a battleship, then, seems to be a thing to avoid, and a moderate speed, which will not detract from fighting power, is the correct answer. We might examine, now, the case of a possible exaggeration of the other factor in mobility, namely, radius of action.

To be sure, we have so far not had cause to fear a loss of fighting power on account of an exaggeration of radius of action. In the past, it has usually been the coal pile which has been robbed, when an extra inch of armor was wanted, or an extra knot of speed, or some other showy thing. It might even have been said that we had not had enough radius of action. The radius that appears in the description of a battleship is the radius she has from the time she joins battle, at least that is the intent. It is the radius at normal displacement, which is supposed to be the fighting displacement.

Viewed from this point, it must be admitted that our fuel supply in normal condition has been large enough, and needs no increase. If a vessel gets into action with a normal supply, she will have enough to carry her through the action, and after

that, who cares? If we win, we can take care of our ships, and if we lose—what does it matter? We would lose the ships too. Remember, we are speaking of a fight to the finish.

The same reasoning as before holds here too. A little more or a little less normal fuel does not affect fighting power seriously. It might even be said that, since our present normal supply is of the order of five per cent of the displacement, there is no danger of loss of fighting power, no matter what is done, so long as excessive increase is not contemplated.

Until the battle becomes imminent, there are various ways of maintaining the battleships, but they do not affect fighting power. We have contemplated fueling at sea, and we have prepared to carry emergency fuel. Either can fulfill the object, and neither affects fighting power.

Having fixed on the policy that in the battleship a definite, large percentage, as large as possible, of the displacement, should be given to fighting power, and no reduction, for secondary purposes, tolerated, we might at some length discuss the proper division of the displacement, or cost, among the elements of fighting power.

Before undertaking this it will be well again to state that there is no limit to the future development in size, nor in speed, nor in any other quality, but these qualities should retain their proper relative magnitudes. There is bound to be increased size. It is just natural development of the species. We now believe that the Panama Canal is a final limit. It is not, nor will any other present or future hindrance be. When we come to the point where the canal is too small for the ships we want to build, we will ignore the canal, or we will enlarge it. Development is as sure as fate. And with development of size goes development of speed, of gun-power, of armor, of everything. Increased size always means increase of some one factor in the ship, and as long as the different factors remain at about their proper relative values the fighting power increases.

Fighting power includes offence and defence. It might be stretched to include most of the general characteristics of the hull, such as length, beam, metacentric height, etc. The length and metacentric height are the most important of these, from the point of view of fighting.

A battleship should not be longer than necessary, and we should even be prepared to accept some reduction in the efficiency of propulsion, to get a shorter ship. Great length means heavy hull, extra armor and decks, greater target, higher center of gravity, and wetter decks in a head sea. It also requires more weight for torpedo protection. The present tendency, due to the canal limitations, is to increase displacement by increasing length. This has the effect of reducing fighting efficiency.

Metacentric height has an important effect on the efficiency of the ship. There should be enough to prevent great heel when firing a salvo, or turning at speed, but not so much as unduly to cut down the period of rolling. A short rolling period always means much rolling. If a period of about twenty seconds for a complete roll could be obtained, rolling would be almost eliminated, except in the severest weather. Metacentric height is also a factor in the range of stability.

Coming now to the factors more directly concerned in fighting, we will start with torpedo protection. A battleship should be so protected that she can stand a torpedo explosion in any part of the hull without disablement. There is no present difficulty, with our present type, in nearly accomplishing this, and the ship will stand torpedoing several times, in different locations, without great loss of fighting efficiency. The only important parts that cannot now be protected are the rudder, propellers, and shafting, and a hit in their vicinity may mean loss of motive power. It might be possible to improve this situation by a different design of hull, but probably with a loss of propelling efficiency, and whether it is worth while is open to question. There is no doubt, however, that torpedo protection should be thoroughly carried out, and large size is for this object a distinct advantage.

Considering now the armor protection, we can establish it at once as a fact that if the vessel is intended to fight only at long range, as seems to be a favorite idea, there is no need for the side armor, since it becomes a vanishingly small part of the target. This is, however, far from the actual fact. The vessel may have to do some fighting at long range, but how much of her scanty allowance of ammunition can she afford to throw away at long range? Remember that when her ammunition is gone her fighting power disappears.

History shows that never yet has a decisive action been fought between nearly equal forces at long range, and the term is here used in a relative sense, each period having its own definition of long range. The reason for fighting a decisive battle at close range is not hard to find. The offence is a matter of how many effective hits can be made. Therefore we may expect the same thing to come to pass. Why should we attempt to decide a battle at long range? Cannot much greater damage be done at short range? Of course we will suffer ourselves, but we cannot expect to fight without receiving damage. A successful fighter always takes punishment, and is able to withstand it better than his opponent. That is the whole thing in a nutshell.

The battleship must therefore be designed primarily to fight at short range, and secondarily at long range. High spotting stations, kite balloons, elaborate fire control instruments, are all good in their way, and probably useful, and should be developed. The ship may need them at long range. But these things will all be swept away when we come to the really serious part of the fighting. Then we will want thick armor, powerful guns, simple and rugged turret machinery, and plenty of ammunition.

Our ships are not now armored in such a way that they can stand up for a long time at short range. They may do very well at 12,000 yards, but that is not short range. The range can be considered short when say more than fifty per cent of hits can be made, by the average ship. It will also be necessary to be somewhat independent of range-finders and range keeping. These things we cannot expect to survive in a decisive battle. Perhaps we might, for the present, define short range as 5000 yards. If, at this distance, our ships were fighting broadside to broadside, or, as they used to say, yardarm to yardarm, the fifty per cent of hits would probably all be effective, and the damage would be great. We should fit armor that will prevent this.

Inclined armor will go a long way to accomplish this. This is not a new idea. It was used in the *Merrimac* of the sixties. It is used now in our turret fronts. We can incline all our side armor inward at say 45 degrees, and it would be proof at very short range against the heaviest modern projectile, if of the thicknesses now used. It is a delicate problem in stability for the naval architect, but it can be done.

Our barbettes will need greater thickness than they have at present, and should be made considerably heavier. It might be possible to compensate somewhat for this by reducing their heights. This will be touched on later.

Protective decks, of the thickness we now use, are good enough at short range, but as the ship must be exposed to gun fire at long range, provision should be made for it. There is no way of escaping serious damage at long range, if the enemy obtains hits. If the protective deck were made narrower, as a result of inclining the side armor inward, we could afford to make it thicker, but not otherwise. The decks now are so heavy, and their effect on stability so marked, that we could hardly afford to put any more weight into them. The protective plating on our decks now amounts to about 10 per cent of the displacement.

The secondary battery is intended only for protection against torpedo craft. Yet we see a great number of men on our battleships that are used only to man these small guns. The number is quite comparable to that used for the main battery. This does not seem logical. If so many fighting men are really necessary for an object that is quite secondary, the natural inference is that the existence of the type is rather precarious. There is need for depending more on passive torpedo protection, just as against gun fire we depend more on passive armor protection, and less on "a well-directed fire from our own guns." That this is quite logical is indicated by the fact that in our latest ships the torpedo protection is quite as efficient against torpedoes as the armor is against heavy projectiles. A weapon of destruction is intended for the offensive, and not primarily for the defensive. There is of course no objection to smashing a destroyer if we get a chance, though, as has been said before, it is cheaper to have smaller types to look out for that. The secondary battery and its crews should be much reduced.

It is hardly necessary to mention torpedo outfits. It is coming more and more to be recognized that these have no place on a battleship, and the outfits we now fit are considerably reduced from what we at one time fitted. It is to be hoped that at a date not very distant they will be entirely eliminated.

Now, last of all, we come to a consideration of the main battery, the primary weapon of the battleship. There has been so much argument about this matter as to leave us entirely con-

fused; there have been so many different arrangements, numbers, and types, that it is quite certain no logic has governed.

The British have come to the belief that not more than eight heavy guns should be mounted on one ship, but they have been building moderate sized ships, and for a special field of action. It is doubtful whether we could take their example for our own guidance, especially when we build larger ships.

We all have a feeling, which is founded on subconscious conviction, as we have not yet been able to justify it by logic, that a larger ship should have a greater battery; in fact, that we are not warranted in building a larger ship unless we increase the battery in proportion. We can easily justify this idea on the basis of economy. There should certainly be at least a standard percentage, for the offensive, in every ton of displacement, and progress in development would seem to call for an ever increasing percentage. Should not every successive phase in development increase the fighting power of the men on board? Hence the distrust with which we regard a design which doubles the displacement, for purposes of speed, and leaves the battery without such increase.

We may therefore feel justified if, on our larger displacements, we carry a heavier battery than the British have placed on their standard battleships. The difficulty is, however, in making proper use of the larger weight. Shall we use larger caliber guns, or more guns, or longer and more powerful guns?

We have mounted up to six turrets on one ship, and have lost some of our fear of interference between the different turrets. A large number of turrets requires, however, a heavy weight of armor for the individual barbettes, and more is used up in the turrets than if we used fewer turrets with a greater number of guns per turret. The need for a greater amount of armor protection on our ships, so as to enable them to fight at closer range, may force our hand in this respect, and compel the adoption or retention of multiple gun turrets, much as we might prefer not to do so, for reasons of putting all our eggs in one basket. This latter point becomes more serious at short range, and will require more careful consideration.

There would be a certain amount of armor weight available for turrets and barbettes. If we used this weight for two-gun turrets, we would have thinner armor than if we used it for three-

gun turrets, and the difference would be greater still for four-gun turrets. It might be said that the turret fronts are now impenetrable, and need no further weight, even if larger guns were used. That is not the case with the barbettes, and it is these that consume so much weight. The fewer the gun stations, the less the weight of the barbettes for a given thickness.

In a two-gun turret, we expose two guns and their crews to destruction from one penetrating projectile. It has been said that with a three-gun turret we expose three guns instead of two. That is true, as far as it goes, but in this case we can have a thicker port plate, and thicker barbette plating, and so prevent penetration. In the case of a four-gun turret, this advantage is even more pronounced, and in addition we can still further protect the turret by fitting a thick plate between the two pairs of guns, an arrangement that is feasible in this case, but not in the three-gun arrangement.

As far as the strength of the hull is concerned, we need have no fear, on account of a four-gun battery, since the stresses will not be greater than with the two-gun arrangement, if each four-gun turret takes the place of two adjacent two-gun turrets.

It seems therefore to be sound judgment not to go back to the two-gun arrangement, and, further, to go to the four-gun turret as soon as practicable. It would, however, be wise to enlarge the turrets to give the individual guns more room, and to prevent jamming of adjacent guns by a single hit. This would also somewhat reduce the interference between adjacent guns, and improve the ballistics at medium ranges. This can be done, and the power of resistance of the barbette greatly increased, by making it conical, the top diameter being the greater, and the inclination of the elements about 15 degrees.

As regards height of battery above water, we have adopted definite heights for Numbers I and IV turrets. From the point of view of weather and sea, there is no reason why we should use greater heights for the other two turrets in our later ships. This present arrangement, the vertical echelon, has been dictated by two considerations; one is the more compact arrangement, permitting placing the whole battery in a shorter length, the other is the desire for end-on fire. If we retain four turrets, in a larger ship, there should be no difficulty as regards the first consideration. As regards the other, is end-on fire really so impor-

tant? We pay for it heavily in this case; it has been costing us over 500 tons, in heavier barbettes and foundations.

It is no doubt a time-honored arrangement, to get as much end-on fire as possible, and conservatism would dictate retaining it. It arose in the days when fighting at very short ranges was contemplated, when three thousand yards constituted long battle range, when ramming was still finding advocates. This was also the day of the powerful turret turning gear, which permitted swinging very swiftly from side to side, to keep on the target in spite of the quick turn in manœuvering to ram, or to strike an enemy alternately starboard and port. It hardly accords with our present-day ideas of fire control and fighting. There is no doubt that most, if not all, of the fire in action will be on the broadside, and that the vertical echelon arrangement is unnecessary.

The indications are then that we should employ an arrangement of multiple gun turrets, as far as possible on the same level, the forward turrets perhaps being higher than the after turrets. This arrangement will incidentally be quite a help in getting satisfactory stability, as it will not raise the center of gravity so much.

When we have reached the limit of four four-gun turrets, the question again presents itself, how to take care of a still further increase in the main battery. We have now adopted the 16-inch gun. Shall we go to still larger calibers? Undoubtedly we shall. An additional four-gun turret would require a much greater increase in length, which is very undesirable. We would hardly be prepared to put five or six guns in one turret. We can then obtain the increase in battery power only by increasing the caliber, or by increasing the length of the guns, and the latter method has much closer limitations than the former.

Here it would be well to observe that from many points of view it would be better to increase the length and the initial velocity of the guns, rather than to increase the caliber. Thus, penetration of armor is obtained more easily with a small than with a large diameter of projectile, of the same striking energy. A little manipulation of the penetration formulæ shows that the thickness penetrated is proportional to the $\frac{8}{9}$ power of the striking energy divided by the caliber. Therefore, the larger the caliber, for a given energy, the less the penetration. There is

then as much penetration to be obtained with the 14-inch projectile as with the 16-inch, if the striking velocities are in the proportion of 3200 to 2600. Again, the greater velocity will give the required ranges with a flatter trajectory, and thus, at comparatively short ranges, will increase the chance of hitting.

A little consideration will show, however, that although this is all true theoretically, the differences from the customary practice must be rather extreme, in order to obtain reasonable increases in the qualities named. It would not be enough advantage to make it worth while, if the velocity were increased from 2600 to 2800. The difference in the angle of fall would be too slight to make much difference, and the difference in penetration also would hardly compensate for the cost. If, now, we could get a velocity of 3500 to 4000, the effect would be well worth while. This must, however, wait further developments, as we do not want guns that would have an accuracy life of only about fifty rounds. It therefore seems that the larger calibers must come, since that is the only feasible way to increase battery power.

In conclusion, it must again be emphasized that we want fighting power above everything else on our battleships. We want our ton of fighting power for every two tons of displacement. The crews that will fight our battleships in the great deciding battles of the future will need to strike hard, and they will need to survive effective until the work is done. Fighting power is composed of but two things, *offence and defence.*

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

# NAVAL RESEARCH

By COMMANDER C. S. McDOWELL, U. S. Navy

When the Armistice went into effect at 11.00 a. m. November 11, 1918, the whole world was thrown out of adjustment or synchronism. Taking this time as a point of departure, it is necessary for the navy and the world in general to readjust itself to new ideas and new missions. We all believe that the war has not been in vain, but, to make this assumption true, it is necessary that we carefully consider the lessons of the war and profit by them in our plans for the future.

Previous to the war the navy had been gradually developing the policy of closer co-operation with civilian engineering activities, as may be evidenced by its representation on standards committees of various engineering societies, and by its calling on engineering societies and recognized civilian experts along certain lines for help in the solution of special problems. In particular the forming of the Naval Consulting Board may be cited as a recognition, by the navy, of the desirability of having the scientific engineering talent of the country available for consultation and advice where its services were required.

We need not necessarily consider the navy as conservative in only of late adopting such a policy, for it is one which has only lately come to the front in civil life. Formerly in the commercial field the utmost secrecy prevailed as to the research work undertaken, and shop practices employed, by the different companies. It has been found, however, that there is sufficient opportunity for all, and that the advantages of competition and emulation are but accentuated by the bringing of independent interests in close touch with one another under conditions such that their combined experiences and deductions may be co-related, with the result that standard rules and practices may be expressed.

The war has brought out, or at least hastened the development of, an enlightened policy between the Government and the various organizations of the country, and between nations as well, which may be considered an innovation. It consists of the pooling of experiences and opinions, without reservation, and the active co-operation of all concerned.

The world may be considered at present as in a nascent state; new plans can be put in actual practice now without the overcoming of inertia of settled conditions such as will exist within a few months. The immediate future, then, should be considered as the days of golden opportunity in applying the lessons of the war, rather than as a time of reaction and inactivity.

It is my idea, in this article, to present the needs of Naval Research and to show that now is the time to formulate a definite policy and make definite plans for such research, including a continuation of much of the work of this nature which was started during the days of the war under emergency conditions. Very few of the ideas here presented are original, but serious consideration of them by the navy at this time is of great importance to the future of the navy and the country.

To show that there is nothing new in the statement that Naval Research is necessary in order that there should be proper progress in the navy, the following extracts from a paper written by Admiral Melville in 1902 are quoted:

> The success of Germany can be accounted for only by recognizing the fact that study, reflection, and *research* must have been expended in the preparation of plans, in the building up and the organization of the shipyards, and in laying out and carrying on the work of construction. It was the high appreciation of the value of *original investigation*, coupled with experimental work, that has caused Germany to advance progressively and successfully.
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> For over a hundred years Germany, as a nation, has carried on more *original* research along technical lines than any other power. While it is true that both England and America have put to practical application the principles discovered by German research, thereby gaining commercial and maritime advantages, it has been the Teuton who has sought after principles.
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> The cost of maintaining a battleship in commission will approximate $1000 per day, and warships have been tied up for weeks on account of the corrosion of a few hundred dollars' worth of boiler tubes. It will repay the nation for the cost of an experimental station if the staff of the

laboratory will simply cause increased length of life of both boiler and condenser tubes.

It is methodical, thoughtful, and persistent work which counts, and as the Germans exceed in this respect, the engineering world is now beginning to understand in its fullness the value of the work done at the German engineering laboratories in promoting German success in both naval construction and maritime development.

It is an anomaly that the greatest of military nations should be the first to appreciate the scientific attainments and capabilities of the engineer, and it is for this reason that Germany has a start of at least five years over England, France and America in systematic naval engineering research. In all probability each of the three other nations has spent more money than Germany in experimental work, but German expenditure, in great part, has taken place before the article is manufactured or the ship is laid down, while in the case of some rival powers, tests and experiments have been conducted to discover means of overcoming avoidable defects.

The proverbs that "an ounce of prevention is worth a pound of cure" and that "a stitch in time saves nine" are as applicable to-day as they were in the last century. It is for this reason that the preparatory experimental work conducted by Germany has been productive of greater results than that done by rival powers working in the direction of seeking remedies for existing evils.

The cost to the British Government of using the cruisers *Hyacinth*, *Minerva*, and *Hermes* for comparative boiler tests and experiments will approximate more than the cost of establishing and operating both the Charlottenburg and the Dresden stations since their inception.

Experience has shown that the German engineering laboratories are more than a good paying investment, for there is not an expert in that empire familiar with the work being done at these laboratories who does not believe that their destruction would be a greater national calamity to the navy and the nation than the loss of one of the battleships of the home squadron. The warship could be replaced in four years. It would take six years to rebuild and put in effective operation the complete installation for conducting experimental research that has been developed and perfected at the Charlottenburg and Dresden technical colleges.

It can be absolutely stated that the navy is behind the times in original work and research—one of the marine superintendents of one of the Great Lake transportation companies told me that if he were called upon to retrench in expenditures the last item to be cut down would be that for experimental purposes, since both the cost of construction and the expense of operation of the steamers under his control had been reduced as a result of the data secured from experimental work. There is not a leading university, large manufacturing concern, or great transportation company that does not consider it imperative to make tests and experiments. Every navy will also find that it will increase efficiency and promote economy to conduct and to encourage extended investigation of unsolved problems relating to its marine service.

This estimate of German research was written a number of years before the war, and we may now be inclined to look with distrust on such research on account of the uses to which it has been put. The fact that the Germans have prostituted research should not be an excuse for our failure to recognize the great advantages of research when properly applied. If the allied nations had patronized research before the war to the same extent as the Germans, the submarine frightfulness, the use of poison gas, and other devilish schemes of the Germans would have been answered immediately, and they would have been no real menace. The Allies soon recognized that intensive research was necessary in order effectively to combat the Germans, and by means of such research were able to find the answer to all the German schemes. At the end of the war the Allies were scientifically superior to the Germans and had proved that scientific research when combined with *right* must prevail. We have heard of many things which won the war, and there is more or less truth in all these claims, but we desire to state, with a great deal of confidence, that the war was won by *research.*

Research is defined in the Encyclopedia Britannica as "the act of searching into a matter closely and carefully, inquiry directed to the discovery of truth, and in particular the trained scientific investigation of the principles and facts of any subject, based on original and first hand study of authorities or experiment." We are inclined, however, to give the word a more restricted meaning and apply it to the investigations of those who devote themselves to the study of pure, as opposed to applied, science, to the investigation of causes rather than to practical experiment.

Dr. W. R. Whitney in a recent paper on "American Engineering Research" defines research as "painstaking investigations which add to knowledge." Adding the word "naval" we obtain a definition of the title of this paper as "painstaking investigations which add to naval knowledge." It will be noted that this includes both theoretical and applied scientific investigations and that all improvements which are to be adopted by the navy in any line must be based in some way on such naval research. If we are content to follow the lead of other nations or to use apparatus and devices as manufacturers may bring them to the navy's attention, we may continue without any definite policy

on research. If, on the other hand, we are to take a leading part in naval and maritime matters, we must have some definite plan of procedure so that the present needs of the service may be taken care of, and the new scientific discoveries be applied to improving the efficiency of the service.

It has been said that not one in a thousand of the many inventions and suggestions submitted to the government during the war by outside parties was worthy of any consideration, and that not one in a hundred of those worthy of consideration were in form for adoption without considerable research and experimental work. It is believed that the above statement is if anything optimistic. The new principles, apparatus and devices which were developed and used in the war were the result of careful and diligent investigation and experiment by persons devoting their whole time and purposes to new problems, and with which they had to be more or less familiar. Experience has been in clear contradiction of the rather universal idea of the country that we simply have to express a need for some new device or apparatus and the American genius will arise with the answer. Natural talents are of little avail, but, with orderly training and opportunity for expansion of intellect, such talents become of great value.

Although the testing of untried and doubtful devices that may be brought to its attention is a function of the navy's research and experimental work, this should not be considered as the major work of the research organization. It is necessary if our navy is really to be efficient, that it should originate new developments and keep ahead of the times. In other words, it should be a leader, rather than simply following the lead of others and simply testing out ideas which may be presented to it.

There was an enthusiastic response from the scientists and engineers of the country to the navy's request for assistance in solving the problems suddenly thrust upon it by the declaration of the war and the realization of the fact that many things had to be accomplished in a hurry if the war was to be successfully pursued. These men before they could intelligently undertake their work had to become familiar with the service needs and service conditions and become indoctrinated. This was accomplished in the case of a great number of these, but much time was lost and work was carried out at much greater expense

than would have been the case if a nucleus naval research organization had been in operation during peace with a personnel familiar with the service and existing conditions.

It must be realized that research serves two purposes: to develop matériel and to develop personnel. The mere construction of laboratory buildings and providing of research facilities will not meet the needs of the service nor solve the problems of the service. The development of men capable of solving naval problems as they are presented might well be considered as the primary object of a research organization.

Dr. F. B. Jewett, chief engineer of the Western Electric Company, in a recent address before the Royal Canadian Institute on the subject of "Industrial Research," spoke as follows in regard to the research work of his company:

> Even to-day and despite the aggregation of human and material resources which have placed our laboratories in the front rank of industrial research organizations, there are on my list a large number of problems which we are not in a position to undertake. These problems, which are directly and solely in the communication field, are problems of major interest to the industry and are of such a nature that we are absolutely sure they can be solved with positive results of inestimable value to the telephone and telegraph companies and to the public at large, provided only that their solution can be obtained through the application of well organized industrial research. Why then do these problems lie essentially untouched? Is it because of a lack of material facilities, of money, of courage to go ahead, or the feeling that these particular researches will not recommend themselves to the business men who are responsible for the commercial destinies of the telephone and telegraph systems? It is none of these. There is no lack of money, no lack of material facilities, no lack of courage, no lack of approval on the part of directors, for we have long ago learned that material facilities are easy to obtain, that money spent in properly directed fundamental research, large though the sums may be, is small in comparison with the direct and indirect returns, and finally that apparent courage in deciding to go ahead is not so very courageous after all when it is exercised by men of ability, training and experience who have shown themselves competent in their own fields, whether those fields be within the laboratories or within the precincts of the executive offices.
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> What then is it that should stop us from an immediate attack if we are so sure of the ultimate result? The answer is the simple, three-letter word "men." Not mere human male bipeds, but men endowed by nature with at least a modicum of the spirit of scientific research to which has been added, either through fortune, personal initiative, parental solicitude or a far-sighted policy on the part of the state, that orderly training and opportunity for expansion of intellect without which natural talents are of little avail.

Our case is typical of the situation which confronts every industrial research organization on the continent. The matter of an adequate supply of properly equipped and trained investigators and directors of research is absolutely vital to the growth of industrial research, and I am as sure as one can be of anything in the world that all of our visions of the benefits to be derived from a large expansion of industrial research will come to naught if we fail to realize or neglect the fact that in the last analysis we are dependent absolutely upon the mental productivity of men, and men alone, and that we must in consequence provide adequately for a continuous supply of well trained workers.

The navy might, by keeping in touch with developments in other navies, utilize apparatus and methods that were fairly advanced and up-to-date, but this system fails when new problems are presented in an emergency, as during a war. Also if we have developed men capable of handling all naval problems and carrying out original research on them, we need not necessarily hold secret the nature of the various apparatus which we have developed and are using,—the knowledge, based on experience, which is locked up in the brains of the research men, and men trained in the use of the apparatus cannot be transferred or obtained by other countries unless they have actually had similar experience and training.

Some of the personnel in a proper naval research organization should consist of persons making this their life work, while certain of the personnel might well consist of officers who have specialized in a particular line and would be given an opportunity to devote a certain number of years to research along their specialty.

A large number of eminent scientists and research engineers of the country have been connected, during the war, with the navy and its activities, in one way or another, and become more or less familiar with the navy. Contact should be kept with these men in civil life and their interest in the navy maintained, so that when particular problems arise on which they are more or less specialists their services may be called for, as required. Also these men in their work in civil life will at times make discoveries or become cognizant of facts which have naval applications, and they should be encouraged to keep the navy informed of such matters. Arrangements could well be made for a certain number of eminent civilian scientists to come into the organization for active duty for a period of a year, to go back to their universities or outside employment at the end of

that time and be replaced by other scientists. The navy, by this plan, would be kept in touch with outside researches and developments and the civilian scientists would be kept in touch with, and interested in, the navy and its problems.

The question may naturally arise as to the possibility of doing much of the naval research work in outside laboratories, or at the Bureau of Standards. It is considered that this is impossible and that the navy must have its own research organization and its own laboratories and application stations. Naval research must be directed and carried out by personnel intimately familiar with the naval problems and service conditions. The writer put the question to the scientific director of the British Admiralty as to the advisability of utilizing the British National Physical Laboratory for the pure research work of the Admiralty rather than establish a separate Admiralty Pure Research Laboratory in London. It was found that the British idea was the same as expressed above: that naval research must be directly under naval control and that the personnel directing and conducting such research should be thoroughly familiar with the naval problems and conditions.

It is hardly necessary, or indeed possible, to give at this time a list of naval problems which require research and experimentation. Also, needs will develop as researches are carried out, which cannot now even be given names. However, to show the scope of the work which it is considered should be covered by naval research, the following partial list of desirable problems may be stated:

Bearings and Lubricants,
Diesel Engines,
Electric Arc Welding,
Erosion (guns, turbines, etc.),
Fire Control,
Light and Illumination (including searchlights),
Optics (range finders and periscopes),
Powdered Fuel,
Radio,
Sound (including the use of underwater sounds for navigation purposes),
Steel Alloys,
Turbines.

It will be noted that, while some of these problems may be considered as purely military, the majority of them have wide application to the merchant marine and to the country in general.

The advantages which have accrued to the navy, as a result of preliminary research on two of the above subjects, are cited:

1. *Electric Welding for Marine Work.*—An investigation of the use of electric welding for navy work was carried out at the New York Navy Yard in 1914 and 1915, and the navy was ready to use this method for repairing of the ex-German ships when they were taken over by the United States, with the result that these vessels were ready for service much earlier than they could otherwise have been. The value of this knowledge of the possibilities of electric welding for repair work was probably worth more to the navy than has ever been spent by the navy on research.

During the war considerable research on electric welding has been carried out and much has been learned. There remains, however, much to be learned on this subject, and it appears desirable for the navy to carry out further research on this problem.

2. *Searchlights.*—The navy has for a number of years been carrying on investigations and researches on searchlights. There is no particular reason for commercial companies carrying out research on this problem as long as they have a satisfactory commercial product. The improvements in searchlights of the present time over those of a few years ago have really been forced by the navy. This is as it should be, for the navy is the user of this apparatus and is the party directly interested in having the most efficient obtainable. It may be noted that the British services maintained during the war a searchlight laboratory in London which was directed by a searchlight council made up of representative officers of the navy, army and air service. There were officers on this council from the Admiralty, the war office, the air office, from the forces in France, the fleet, H. M. S. *Vernon,* etc., and all questions of experiments, types of apparatus, and quantities to be manufactured, and allocation of finished apparatus, were decided by this council. The writer attended a meeting of this council and was very favorably impressed with the manner of carrying on

this work and the co-operation which obtained between the various services and interests involved. There are at present, however, fundamental facts in regard to military searchlights which remain to be investigated. Undoubtedly careful research will produce a much more satisfactory apparatus than we now possess.

In research, applying this term in its broad sense and including both theoretical and applied investigations into the matter, there are two general types of problems with all gradations between:

(a) The problem of a pure research type, exploratory and fundamental in character, and involving work of a high order in physics, chemistry, mathematics, etc.

(b) The problem of industrial development and application, involving thorough engineering, design and manufacturing ability, and experience of the service conditions to which the apparatus or material will be subjected.

The man who is interested in the problem of a pure research type, and is most competent for work of this character, is not generally interested in its engineering application, except indirectly, and for efficient work should not be burdened by consideration of that side of the question, except as necessary for effective direction of his own work as a whole. This man should, however, be familiar with the navy service conditions so that he may realize the difficulties and restrictions imposed by service conditions. He is generally not competent in the applied side of the problem and any attention given by him to that work, except as necessary to better understand his own part of the problem, is inefficient. On the other hand, the engineer who is competent in design, development and production, to meet service conditions and service needs, is generally not especially interested, nor competent, in the pure research side of the problem. To properly carry out his work, however, he must have a general understanding and appreciation of such pure research work, in order to secure effective co-operation.

At the naval experimental station, New London, Conn., the demarcation, as given above, between the two divisions of research and development work, has been generally followed, with, however, a liberal interlocking of the two divisions. The experience of this station tends to show that this organization is cor-

rect and satisfactory. It is believed that those industrial-engineering organizations that have recognized the above situation and have developed two groups of men in their research-development divisions, with close contact between the two groups, have secured the most effective organization, and that their experience under the emergency conditions of war has proved this system to be most satisfactory. Substantially this is the form of organization of the General Electric Company, the Westinghouse Electric & Manufacturing Company, and the Western Electric Company, as well as others.

It is believed that the navy should organize two such groups of men to handle its research and development problems, these two groups, while distinct, being in as close contact as possible with each other. It is probable that the majority of the arguments would favor the creation of a centralized laboratory and staff in the vicinity of Washington, devoted to the pure research work and the development of such apparatus as does not require sea experimentation or trials with various types of craft, and the maintaining of such other stations, as the naval experimental station, New London, as may be necessary for the applied engineering development and manufacture of material and apparatus in small quantities until the type has proved satisfactory and can be turned over to manufacturers for quantity production. The groups on the applied development work should be located where local advantageous conditions dictate, but it will, of course, be most effective to bring as many of these groups together in a given location, and to maintain as few stations for such work as possible. It may be pointed out that this suggested plan is quite similar to that of the Department of Agriculture, with its centralized laboratory and staff in Washington, and its distributed experimental stations in each state for study and application under the local conditions of soil and climate.

As previously stated, the personnel side of research work is considered of greater importance than the mere providing of laboratory buildings and facilities, although these latter are, of course, very necessary. It is desired to emphasize, though, the fact that the mere creation of buildings and equipment will not in itself provide the effective research which the navy requires.

As the head of the navy's research organization there should be provided a director of research, probably under operations, and associated with him a research council. This council to be made up of representatives from all the bureaus, from the different forces of the fleets, and, possibly, from the bureau of standards, and probably including a few eminent civilian scientists and engineers,—care being taken not to get a body too large and unwieldy. It would be best to have a small executive council, and allow for calling in of other members when problems, of which they were particularly cognizant, were to be considered.

The close tying together of the different bureaus by their representation on the special board on anti-submarine devices has been of the greatest value to that board in effectively carrying out its mission, and it is believed to have been of considerable value to the bureaus as well, by keeping them closely informed of the work under way and the results being obtained. The close cooperation obtained in England in several organizations combining naval officers, civilian scientists, engineers and manufacturers, was particularly noticed, and it is believed, as a result, that very effective and expeditious work was carried out by this procedure.

Assuming that the departmental part of the research organization can be taken care of, the real difficulty of naval research presents itself. This is the obtaining of the proper grade of research scientists and engineers. The following plan is proposed:

(a) Select a group of naval officers who have shown an inclination toward engineering and scientific research and who are interested in carrying out intensive investigations along their specialties, these officers to be available for this work for a term of years in either administering or actually carrying out research.

(b) Elect each year five or more eminent scientists for a one year appointment as professors of mathematics in the navy (or possibly as lieutenant commanders (technicists) in the reserve force) to serve during a year's leave of absence from their universities or civilian employments.

(c) Designate each year a certain number of Naval Academy graduates to the naval research laboratories for postgraduate work, and provide instructors for them, these officers to specialize in research in the same manner as

officers are now given postgraduate work and specialize in ordnance, electricity, radio, steam engineering, naval construction, etc.

(d) Obtain a sufficient number of young scientific graduates from universities to take up scientific work in the organization, either temporarily or permanently.

(e) Each summer invite at least ten professors or other civilian scientists to carry out investigations at the central laboratory or associated experimental stations.

At the research laboratory ample opportunity should be afforded for research on any problem in physics, with an opportunity for the investigator to publish the results in a journal established at the laboratory, which journal should have a wide circulation throughout the navy, and among civilian scientists and engineers. It is well known that a scientist's chief reward and chief incentive for his work is the acknowledgment of his work, and the credit which is given to him for original investigation or development, by other scientists and the world in general.

It may appear that the navy would not sufficiently profit from its research work unless its results are kept as naval secrets, and it will be seen from the plan here outlined that it is proposed to give publicity to the research work. It is believed that in most matters, if not in all, there is more profit in developing competent men to produce results, than in the results themselves, regarded as naval secrets, for, in the case of national stress, these men can be called upon to use the organization to meet the emergency. It is also felt that many of the applications, arising from the researches undertaken, would be desired for the merchant marine, as well as the navy, and that therefore the navy could not properly restrict them to its own use.

By adopting the scheme for obtaining personnel as suggested above, new blood and new methods of attacking problems would be continuously brought into the organization. Contact would be closely maintained with the civilian scientific developments and researches of the country, without losing touch with the navy's needs and desires. In this scheme there should be no danger of naval research getting into a rut, while at the same time there would be developed, both in the navy and out of it, a trained research personnel capable of understanding and solv-

ing various naval problems as they were presented. The navy would become acquainted with the applications of research to its problems, and the civilian scientists of the country would become acquainted and interested in the navy and its problems.

In the navy we have been inclined to think of a scientist as a long haired crank whose mind is full of complex mathematical formulae and obtuse theories, and that he could be of little or no assistance to us. Many of us, though, who have come in direct contact with real scientists, have found that they take a real interest in our problems, and knowing, as each of them does, some special application of natural laws, they have been able to point out naval problems which we did not realize existed. That is, individual scientists, when acquainted with service conditions, have been able to show that some of their special knowledge of physical laws could be applied so as to simplify our ways of doing some particular thing, and thereby improve the naval service, while we in our ignorance would have been satisfied with things as they were and never realized that better and more efficient ways could be devised.

Let us realize then that the essence of ability is the same in all people, be it naval officer, scientist or business man, and that their minds are really much closer together than we usually grant.

Given, then, a close co-ordination between the proper types of naval officers and scientists, the navy should, in its research organization, become the greatest patron of science in this country, if not in the world, with resultant improvement and progress, not only in the navy, but in the whole country.

REAR ADMIRAL RALPH EARLE, U. S. NAVY, CHIEF OF BUREAU OF ORDNANCE.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

# U. S. NAVAL RAILWAY BATTERIES

By LIEUT. COMMANDER L. B. BYE, U. S. Navy

When the history of the great war is written, the various activities of the United States Navy in co-operating with the Allies and in contributing in various ways to the offensive measures which finally caused the downfall of the enemy, will be disclosed. The navy's work in transporting troops, the operations of the destroyer flotilla, the convoy system, the activities of the naval bombing squadrons, the success of the North Sea mine barrage, and the many other naval operations conducted at a distance of 3000 miles through Vice Admiral William S. Sims, commander, United States naval forces operating in European waters, will emphasize the fact that the United States Navy was a big factor in overcoming the submarine menace and causing the ignominious surrender of the demoralized German fleet. This article will describe the navy's contribution ashore in the great battles during the closing days of the war with Germany.

The navy actually had engaged on the Western Front from September 6, 1918, until the signing of the armistice, five 14-inch 50-caliber guns on railway mounts which were designed and built under the direction of the Navy Bureau of Ordnance, transported to France, erected and put in operation at a time when the necessity for such long-range weapons was vital. The story of this accomplishment is believed to be of interest to all readers of the NAVAL INSTITUTE PROCEEDINGS.

From the beginning of the European War the range of artillery both on land and at sea attracted a great deal of attention. Mounts and guns of increasing range were continually being produced by both the Allies and the Germans. At the time the United States entered the conflict, this competition of long-range guns was at

its greatest height, with the advantage on land decidedly in favor of the Germans.

In the early part of November, 1917, a report was received from Lieut. Commander G. L. Schuyler, U. S. Navy, giving information concerning the maximum range of German guns, mounted near Ostend, which were firing into Dunkirk. These guns were known as the "Leugenboom" guns, and it was ascertained by the British that they were capable of a range of as much as 50,300 yards, or slightly over 28½ statute miles. None of the British guns in this sector could equal this range, and it was evident that the Germans were making great strides in modifying their naval guns so that they could be used on land for long-range bombardments.

In previous wars, the personnel of the navies engaged gave valuable assistance to the armies by landing parties from ships manning naval guns. During the Mexican War, three 64-pdrs. and three long 32-pdrs. were used by General Winfield Scott in his attack on Vera Cruz. During the Boer War one of the British cruisers was practically stripped of her guns, they being taken to Ladysmith, Colenso, and Spion Kop. Naval guns were used during the Boxer Rebellion in China.

The French, English and Germans in this war manned their naval guns on shore with naval personnel. The traditions and calling of the sea naturally led to this practice, as being the most promising one to adopt to attain the most satisfactory results. The guns and their mounts are heavy and differ in many respects from those ordinarily used by armies. Many different difficulties arise which are recognized by seamen as things to be overcome without outside help. Stress of weather and life at sea have imbued the seaman with the idea that on him alone does his own safety and that of his shipmates depend. He must be a doer, and on the moment. The cruel sea waits for no man. This feeling of self-reliance, instilled in the seaman, makes his character peculiarly suitable for such enterprises as operating naval guns on shore. The Bureau of Ordnance was giving particular study to events of the war, and was continuously endeavoring to formulate some plan whereby the ordnance resources of our navy could be brought into active offensive engagements with the enemy. The Navy Department welcomed suggestions from all of its personnel, and

circular letters were sent out to the entire service requesting any person in the service to submit such suggestions as he might have for the improvement of the material of the navy, any ideas for a plan of attack or any scheme for defeating the Germans.

Rear Admiral Ralph Earle, the chief of the Bureau of Ordnance, was so impressed by the progress of the long-range bombardments on the Western Front that, on November 12, 1917, he suggested to the chief of naval operations the possibility of mounting several naval 14-inch guns along the Belgian coast as an answer to the long-range German bombardments of Dunkirk.[1]

The possibilities of this plan appealed to the chief of naval operations, and he requested that the plan be developed in more definite terms as to the number of guns and mounts available, the probable range, the time necessary to prepare for shipment, and the material required to accomplish such an expedition. The United States Naval Gun Factory, the right arm of the Bureau of Ordnance in the many problems connected with the design

[1] November 12, 1917.

From: Chief of Bureau of Ordnance.
To: Chief of Naval Operations.

Subject: Long-range bombardments.

1. From reports of activities, dated September 29, 1917, along the Flemish dunes, the Bureau notes:

"On the Dune Sector, the British naval guns were unfortunately considerably outranged by the German guns. There are no British guns larger than 12-inch mounted on shore here. The big German gun which fires into Dunkirk is generally referred to as a 17-inch. . . . . Its range has been measured as 50,300 yards."

2. The above suggests the possibility of our mounting several naval 14-inch guns along the coast, fitted with high angles of fire, and with specially formed shell, fitted with delayed action fuses, in order to outrange these German guns. Manned by our seamen, a battery of four of these guns might not be a bad answer to the long-range German bombardment of Dunkirk. Of course, in order to develop this range the bureau must have its auxiliary proving ground granted and operating.

3. Even were the guns mounted on vessels off the Belgian coast, and there given a range of over 30,000 yards, considerable damage may be done to German positions. Such a vessel fitted—as it would be—with our new, smoke-producing apparatus, might materially assist Admiral Bacon's monitors in their operations.

(Signed) RALPH EARLE.

and manufacture of naval ordnance, was informed on November 28 of Rear Admiral Earle's ideas, and was requested to make recommendations concerning such an expedition. The calculations of the Bureau of Ordnance indicated that with the standard 14-inch naval shell then available, a range of about 48,000 yards could be obtained with the 14-inch 50-caliber gun. Figures as to what a light 14-inch shell would do were gone into, and it was indicated that a range greater than that obtained by the German "Leugenboom" gun might be expected. The navy's 16-inch gun could easily have outranged those of the Germans, but it was unfortunate that at that time 16-inch guns were not available in sufficient numbers.

Fourteen-inch ammunition in quantity was on hand, and by the entire personnel of the Bureau of Ordnance it was believed entirely feasible to provide all the equipment necessary for the operation of ten 14-inch guns on shore, if such an undertaking should be decided upon. The shipment of 14-inch 50-caliber guns abroad was known to be feasible, for during the summer of 1917 shipments of 14-inch 45-caliber guns had been made without difficulty to the British Admiralty. It appeared from all investigations made in the bureau that if a suitable shore mounting could be developed the navy could have in operation in France a number of 14-inch guns within a period of six months from the time of approval of such a project.

The Bureau of Ordnance considered the subject from all points of view, and discussed the project with many officers. The deeper the matter was gone into the more enthusiastic they became, and the more certain they felt that if these guns could be placed at some point in Flanders and operated by the navy, a useful tactical result was probable of attainment, and valuable assistance would be rendered to the Allied armies.

The drafting-room force at the Naval Gun Factory, under the supervision of Commander Harvey Delano, U. S. Navy, had been over-worked from the beginning of the war, in developing the vast number of new naval ordnance designs which were under way. Nevertheless, they became so interested in developing a suitable device for countering the long-range bombardments of the Germans that they completed their preliminary investigations on

December 10, and submitted to the Bureau of Ordnance an outline descriptive of a shore mounting for the 14-inch 50-caliber gun, Mark IV.[2]

The gun factory's thorough efficiency is demonstrated by its letter, which the bureau forwarded, without change, to the chief of naval operations, urging that an undertaking of this sort be approved.

[2] Bureau of Ordnance

December 10, 1917.

Subject: Shore mounting for heavy guns.

Inclosure: Description of above mounting for 14-inch 50-caliber gun, Mark IV.

1. There is forwarded herewith a description and accompanying plates of the proposed railroad mounting for the 14-inch 50-caliber gun, also a description of the train carrying the personnel and equipment necessary for the operation of such a gun in the field.

2. It is the intention to use the 14-inch 50-caliber gun, Mark IV, mounted in slide Mark IV. In order to mount this gun and slide on the proposed railroad car, it will be necessary to make a new deck lug and jacking mechanism for raising the gun from the stowed position necessary for transportation to its firing position. A new elevating gear of the arc and pinion type will be required, as the screw type now used will require raising the gun too high from the tracks for stability in transporting.

3. The railroad mounting and equipment for a gun of this size will be of great value in assisting to overcome the fire from large German guns now being used against the lines of the Allies "on the Dune Sector" in Belgium. In addition to this advantage such a railroad mounting would be of considerable value in this country as a mobile battery to act in conjunction with the army in case of invasion.

4. It is estimated that four gun cars and their accompanying trains can be constructed by contract within 90 days after the receipt of drawings, provided the work can be given government priority, both in securing the material and the manufacturing work involved. It is estimated that by giving this work precedence in the drafting room, and with the hearty cooperation of all concerned, the drawings and necessary specifications can be completed by the 1st of February.

5. It is recommended that four gun cars and their trains be manufactured, making four complete batteries of the type described in the accompanying description, and that the six remaining 14-inch 50-caliber guns with the slides be held as spares to replace any of the guns in the battery when worn out or injured.

(Signed) A. L. Willard.

The chief of naval operations consulted with the various bureaus concerning their part in the plan in furnishing men and materials other than those which could be furnished by the Bureau of Ordnance. The entire project appeared to be justified in view of the shortage of long-range artillery, as known to exist in the Allied armies, and, on November 26, 1917, the Navy Department approved an organization of five 14-inch railway mounts, with a complete train equipment for each gun, and a sixth train to accommodate the staff for communication between the five batteries when in action at various positions along the lines.

To Lieut. Commander L. B. Bye, U. S. Navy, fell the task of coordinating all efforts to accomplish the manufacture and shipment of guns, mounts, carriages, cars, locomotives, and all other necessary equipment.

The Bureau of Ordnance was instructed to go ahead. Battleship turret-mount designers, together with other men at the Naval Gun Factory, experienced in bridge and locomotive work, were called into action to develop the detailed plans along the lines of their preliminary investigations. Directed by the superintendent, Captain A. L. Willard, and by Commander Harvey Delano, U. S. Navy, the officer in charge of the drafting room, the work moved forward in spite of all discouragements. Holidays and Sundays were sacrificed, and every effort was made successfully to meet on the drawing board all problems connected with this project. Many problems which had not been anticipated were encountered, and it was necessary to refer to all data on French railways and French railway practice that was available in the United States, and also to communicate with the commander of the United States naval forces operating in European waters, for confirmation of data, for it was found that in many cases reports were conflicting.

The excellent work of George A. Chadwick, leading draftsman at the Naval Gun Factory, during these trying days, was very remarkable, for it is due to his excellent judgment and to his confidence and devotion in the solution of the many questionable points connected with the new features in these railway mounts, that they fulfilled their many requirements for service in France.

The Naval Gun Factory is to be congratulated for its remarkable and prompt work in the completion of the excellent designs,

not only of the shore mounts for the heavy guns, but for the equipments and organization of the complete expedition. One hundred thirty-six standard drawings and eleven sketches were ready for submission to the bidders on January 25, 1918.

In order that the immense amount of work in connection with the design and building of the United States naval railway batteries may be understood, it may be generally described as follows:

Each 14-inch naval railway battery was a complete self-sustaining unit, designed to operate individually or in conjunction with the several similar batteries. When two or more batteries were cooperating in the same sector, their activities were directed by a single commanding officer, with headquarters on the naval railway batteries staff train. Fundamentally, each battery consisted of a 14-inch 50-caliber naval rifle carried on a special railway mount, together with ammunition cars and auxiliary cars. The gun, with a muzzle velocity of 2800 foot-seconds, had a maximum range of 42,000 yards. Firing could be effected between angles of zero to 43° elevation. At angles of elevation ranging from zero to 15° the gun could be fired with no support other than the trucks. For firing at any angle within the range of 15° to 43° elevation, it was necessary to place the gun car over a suitable pit foundation to allow clearance for the 44-inch recoil of the gun. When on this foundation the mount was fixed, and its position remained the same for successive shots, while, when firing at the lower angles upon the track, the energy of recoil was absorbed by the car which traveled backward on the rails against the resistance of tightened brakes.

The railway battery was designed to provide utmost freedom from difficulties associated with auxiliary power-driven accessories and from dependence upon a supply base. With exception of a small, combined air-compressor and winch, driven by a single gas engine, the mechanical functions of the battery were performed solely by hand power. Compressed air was used in operating the breech mechanism and in the counter recoil cylinders. Each battery train was provided with ample supplies and spare parts, augmented by stores and equipment carried on the staff train. The cars of the battery train provided facilities for foundation erection, repairs and quarters for the officers and crew. The scope of the

battery is indicated by the following list of cars which made up a single battery train:

1 Locomotive.
1 Gun car.
1 Construction car.
1 Construction car with crane.
1 Sand and log car.
1 Fuel car.
1 Battery kitchen car.
2 Ammunition cars.
3 Berthing cars.
1 Battery headquarters car.
1 Battery headquarters kitchen car.
1 Workshop car.

The locomotives and all the cars were designed to conform to the regulations of the French State Railways. Exclusive of the gun car, the various cars were standard flat cars, gondolas, and box cars similar to those supplied to the American Expeditionary Forces in France, and they could be used in conjunction with the French railway equipment. The fittings of the battery headquarters, berthing and commissary cars, such as bunks, stoves and other appurtenances, were, for the most part, standard naval fittings which could be replenished at any naval base.

While in France the guns were never fired from the rails at low angles of elevation. In all cases the firings were conducted from the pit foundation and at ranges near the maximum. In all cases there was no criticism due to the necessity for installation of the pit foundation. Ample material was provided for the construction of as many as twelve pits, and there was always sufficient time to prepare a firing position in advance of the time set for moving up the gun. In the preparation of a site for firing, the construction cars were brought to the point selected and were used to handle the timbers and steel frame work employed in the foundation. The gun car was pushed over the completed foundation, the truck wheels were locked by brakes, and the weight of the car was transferred to the foundation by means of jacks and lifting screws. In this position a traversing gear provided for $2\frac{1}{2}°$ train on either side of the center line of the foundation. During action an ammunition car was brought to the rear of the gun car. Ammunition was conveyed to the breech of the gun by a monorail crane in the ammunition car and a shell tray mounted on a track in the gun car. The personnel of each battery was sufficient to insure satisfactory individual operation. In addition to the officers and crew necessary for the operation of the staff train, its complement included medical and engineer officers and a crew detailed to transportation work among the various batteries as cir-

cumstances required. The staff train was made up of the following cars:

1 Locomotive.
1 Staff quarters car.
1 Staff kitchen and dispensary car.
1 Spare parts car.
1 Staff construction car.
1 Staff workshop car.
1 Staff commissary car.
1 Staff berthing car.

For information concerning the details of the gun car the following brief description is given:

The gun car consists essentially of two longitudinal girders, fabricated of steel plates and structural shapes, and provided with suitable transverse stiffeners. The car is run on two front and two rear six-wheel trucks. A housing in the form of an inverted "U" is provided at each end of the girders for the forward and rear jacking beams used for raising the gun car off from the trucks and placing the car upon the pit foundation. Beneath the jacking beam a center pin casting serves as a socket for the center pin of the car truck. A little forward of the center of the car is a transom casting, against which the transom bed plate bears when the car is jacked up on the pit foundation. Cast integrally with the transom is the pin which engages the transom bed plate of the foundation and the lugs that support the oscillating bearing of the elevating mechanism. The transom is rigidly fixed to the gun girders and is designed to transmit stresses incident to firing to the foundation through the transom bed plate, secured to the inboard side of the girders immediately above the transom by the two deck lugs that support the gun.

Each truck has three axles turning in 9-inch x 12-inch brass journals; the wheels are 36 inches in diameter. The incorporation of the 14-inch gun into the gun car was done in such a way that navy standard fittings could be used as much as possible and the gun, gun slide, breech mechanism and deck lugs were of standard navy design, except that slight modifications were necessary in order to provide for elevations up to 43°. The entire arrangement may be likened to a navy turret installation for a single gun of the *Mississippi* class, mounted on a railway car in such a manner that it may be transported over railways, and when placed on its foundation, fired repeatedly at elevations from 15° to 43° and with a maximum angle of train of 2½° on either side of the center line of the foundation.

The counter recoil mechanism as used in these railway mounts is of interest; for, as originally designed, it was not intended that it would function at angles greater than 30°. In order to provide the increased energy necessary to return the gun to battery at the higher angles of elevation, the counter recoil spring cylinders were modified so that the action of the springs could be augmented by a pneumatic system designed to act with the springs in returning the guns to battery. Air was furnished by the air compressor for this system of counter recoil as well as for the gas ejector system, and it proved highly efficient even during continuous firing when charged to an initial pressure of about 125 pounds.

The gun was laid in elevation, for firing, by means of a gunner's quadrant, and for azimuth by a surveyor's transit mounted on a sight support, which extended out from the trunnion and projected through the side of the car. Except in a very few cases, all firings in France were conducted without observation, and the accuracy with which the guns could be laid in azimuth and in elevation for map firing and indirect firing proved to be as precise as necessary.

The total weight of the gun car complete is in the neighborhood of 535,000 pounds, distributed as follows:

| | Pounds |
|---|---|
| Gun, breech mechanism and yoke | 192,500 |
| Slide, complete | 50,700 |
| Elevating gear (screw) | 650 |
| Elevating gear (nut) | 2,930 |
| Elevating gear details | 1,860 |
| Deck lugs (2) | 10,200 |
| Transom casting | 10,000 |
| Cab | 12,400 |
| Shell-loading device | 1,290 |
| Girders, including the braces (2) | 135,830 |
| Trucks (4) | 80,000 |
| Truck beams (2) | 33,000 |
| Compressor, winch and engine | 1,800 |

The pit excavation and gun-car foundation were designed to meet every contingency that might arise in the field. At the same time it was realized that numerous problems of construction and operation impossible to forecast would have to be solved in practice by the personnel. Approximately 103 cubic yards of earth had to be removed for installing the foundation. The pit

had to be dug, and then by means of a crane car the timber work and structural steel girders were put in place. The transom bedplate casting by which the firing reactions were transmitted to the foundations was required to be approximately level, and the pit had to be installed so that the axis of this casting or the center line of the foundation was in the approximate line of fire.

It was at first thought that the necessity for this pit arrangement might be a severe handicap for the operation of the guns in France, for it was known that considerable time would be necessary for its installation. It proved, however, that this means of taking up the reactions of the gun while firing was decidedly superior to other methods in use, where the gun car recoiled for some distance along the track after each shot. The installation of the pit required from 30 to 36 hours, while the gun could be placed over it in from one hour to one hour and a half. When the gun car was once locked on its foundation, the entire mechanism was stable and properly lined up for continuous and rapid shooting.

The story of the construction of the 14-inch naval railway batteries indicates the nation's patriotic speed in manufacturing, machining and assembling material during the war. The most satisfactory feature of the entire project is the manner in which the entire equipment fulfilled all the hopes of the persons who had to do with its construction. The problems that were solved were numerous and their extent is indicated in the preceding pages. In addition to the actual work of construction, a large amount of entirely new and important data had to be obtained by special experimental work. The problem of securing and training the personnel to operate the batteries when completed, and the task of handling the enormous weights and shipping them abroad for reerection in France, the actual assembly work at St. Nazaire, and the difficulties connected with their operations on the Western Front were real ones, and the enterprise was successfully accomplished, not on time, but ahead of time. The guns actually rendered excellent service during the closing days of the great war in firing against the enemy at several important strategic points.

The interval from January 25 to February 13 was consumed in making arrangements for the manufacture of the material. The leading men of concerns in the United States for building railway cars, steam locomotives, and constructing bridges were called

together in Washington. The importance of the project was explained to them, to make them realize the necessity for breaking all previous records of war production if they should undertake the work and complete their part in time to enable the guns to participate in the great offensives that were to take place in France during the summer of 1918. To obtain satisfactory bids for this vast amount of work it was necessary, in placing the contracts, to avoid interference with other important war supplies for the U. S. Army, the U. S. Navy and the Allied Governments.

It appeared at first as though the bureau was demanding the fulfillment of impossible conditions. The engineers representing these large manufacturing concerns were thrilled with its extent and appreciated its possibilities; but the task appeared to them impossible, until, during a second conference, Mr. Samuel M. Vauclain, chairman of the Munitions Committee of the War Industries Board, with his customary delight in undertaking problems which to others seem out of the question, assured the Bureau of Ordnance that the Baldwin Locomotive Works would build the gun cars with the assistance of the American Bridge Company in from 100 to 120 days. The president of the Standard Steel Car Company, Mr. J. M. Hansen, was so stirred by Mr. Vauclain's enthusiasm and patriotism that he also came forward and promised to deliver the entire number of auxiliary cars in the same time. The first step in the actual building of the mounts, therefore, was to award to the Baldwin Locomotive Works the building of the six necessary locomotives and the five gun cars, and to the Standard Steel Car Company the construction of the 72 auxiliary cars. The complete equipment as called for in these two contracts was as follows:

6 Consolidation locomotives and tenders (tractive power 35,600 pounds).
10 Ammunition cars.
5 Battery kitchen cars.
5 Battery headquarters cars.
15 Berthing cars.
5 Fuel cars.
5 Workshop cars.
1 Staff quarters car.
1 Staff kitchen and dispensary car.
1 Staff radio and spares car.
1 Commissary car (staff).
6 Construction cars.
5 Construction cars with cranes.
5 Sand and log cars.
1 Executive officer's car.
1 Staff office car.
1 Staff workshop car.
1 Set of equipment for staff workshop car.

INTERIOR OF AMMUNITION CAR LINED WITH BULLET-PROOF STEEL.

No time was lost in getting started, for the bids were accepted on the day of this second conference, February 13, 1918, and the awards were made by telegraph.

Actual construction of the railway batteries having commenced, the chief of naval operations, on February 19, directed the Bureau of Navigation to provide the personnel for their operation abroad.[8]

Rear Admiral, then Captain, C. P. Plunkett, U. S. Navy, was detailed at his own request as commanding officer of the United States naval railway batteries. It was under his supervision that the personnel was assembled and instructed.

The activities of the fleet during these important days made it impossible to take officers and men from the ships, for they were needed for the duties which they were then performing. In order

[8] February 19, 1918.

From: The Chief of Naval Operations.
To: The Chief of Bureau of Navigation.

Subject: Personnel for Naval Batteries for Operation Abroad.

1. The plans, as approved by the Department, for sending five (5) naval batteries to operate overseas contemplates the following personnel:

1 Commanding officer.
1 Aide (liaison).
1 Medical officer.
1 Supply and pay officer.
1 Clerk.
5 Battery officers.
5 Fire-control officers.
5 Gunners.
5 Machinists.

2. The following enlisted personnel:

5 Chief gunner's mates.
15 Gunner's mates.
5 Machinist's mates, first class.
5 Carpenter's mates, first class.
5 Blacksmiths.
11 Cooks.
16 Assistant cooks and Mess attendants.
12 Radio operators.
1 Hospital steward.
6 Hospital apprentices.
6 Locomotive engineers.
6 Firemen.
6 Trainmen.
60 Fire-control observers.
35 Seamen (gun crew).
115 General ratings, artificer branch (construction crew).

3. Captain Plunkett, U. S. Navy, has been directed to confer with the Bureau of Navigation and Ordnance with regard to the assembling of the personnel and material for purposes of training previous to departure from this country. He will confer with the bureau as to the time and places where this personnel will be needed.

(Signed) W. S. BENSON.

not to interfere with the efficiency of any organization, the personnel was drawn from the naval training stations and rifle ranges, where personnel was being trained preparatory to taking part in the actual operations of the navy. As a result, more than 90 per cent of the complement of the naval railway batteries were men who had no previous experience with naval ordnance material, but they were excellent men who had entered the United States Naval Reserve Force that they might do their part in downing the enemy. They were most attentive in all their instruction, so that with a short course of intensive training, and a little experience on the front, they became imbued with the navy spirit and made good.

The original complement of the batteries called for 449 men and 25 officers. This was later increased to 500 men and 30 officers.

The complement of each of the five batteries was as follows:

Commanding officer.
Construction officer.
Orientation officer.
Medical officer.

ORDNANCE

1 Chief turret captain.
2 Gunner's mates, 1st class.
1 Gunner's mate, 2d class.
2 Machinist's mates, 2d class.
1 Boatswain's mate, 1st class.
2 Coxswains.
1 Electrician, 1st class.
1 Electrician, 2d class.
15 Seamen.

CONSTRUCTION

1 Chief machinist's mate.
8 Ship fitters, 1st class.
8 Ship fitters, 2d class.
8 Carpenter's mates, 1st class.
8 Seamen.

MEDICAL

One hospital apprentice.

COMMISSARY

1 Ship's cook, 1st class.
1 Baker, 1st class.
1 Ship's cook, 2d class.
4 Ship's cooks, 4th class.

The complement of the staff train was:

COMMANDING

Commanding officer.
1 Chief yeoman.

EXECUTIVE

Executive officer.
1 Chief yeoman.

MEDICAL

Senior medical officer
1 Chief pharmacist's mate.
3 Hospital apprentices.

COMMISSARY

Supply and pay officer.
2 Assistant paymasters.
1 Chief commissary steward.
1 Commissary steward.
1 Pay clerk.
1 Baker, 1st class.
3 Ship's cooks, 4th class.
1 Ship's cook, 1st class.

TRANSPORTATION

Transportation officer.
100 Men of various artificer ratings.

(These men available for general duty among five battery trains.)

To indicate the type of men would require many pages in describing their capabilities; but their character may be understood from a letter by Captain Plunkett.

"Select a detachment consisting of the officers or petty officer (in charge) whose name appears in parenthesis above and 30 other men, for most important duty.

"This detachment should include only excellent men. It should include several men who can do machinist work, electrical work, radio work, concrete work, signalling, locomotive engineers and firemen, trainmen, carpenters, painters, plumbers, blacksmiths, automobile men and an assortment of men of various trades.

"It is not intended that all men should be men of trades; the majority of them should be intelligent and active young men, preferably those with some education. It is not necessary that the men have ratings indicative of their trades. Select excellent all around men without regard to rating. Hold this detachment in readiness for orders.

"Submit to the Director of Gunnery Exercises and Engineering Performances a list of the men showing their rates, branch of service, small arms' qualification, the place from which received, the various duties each has performed at your range and a brief statement of his former occupation, education and things he can do.

"Hold this party as a separate detachment. Have it begin an intensive course of training, covering all the navy small arms' courses, including daily firing for each man. Give plenty of practice with pistols and revolvers, or both, and especially plenty of machine-gun practice, each man with each type of gun. Have plenty of practice at 600 and especially at 1000 yards.

"Every man must have a thorough knowledge of the mechanism of the pistol, rifle, and each type of machine gun. Include no man who is unable

As the secret of an expedition to send 14-inch 50-caliber naval guns to the front gradually spread, oral and written requests for detail to this organization were received from at least 20,000 different officers and men. Any person who had the slightest inkling of the project was most anxious to become associated with this work which was to take him into the most active sectors of the firing line.

For instruction, the men were divided among the Naval Proving Ground, Indian Head, Maryland; the Naval Gun Factory at Washington, D. C., and the Sandy Hook Proving Ground, Sandy Hook, N. J., where they were given intensive training. They were required to put guns in place, load and fire them, disassemble them after proof and become so accustomed to gun-fire that they lost all nervousness. The handling of heavy weights or the firing of big guns became to them only a routine matter. They were required to operate trains; operate locomotives; to build railroad track, and perform any sort of task which was likely to give them experience that would be valuable while operating against the enemy. A number of men were assigned to the Baldwin Locomotive Works and to the shops of the Standard Steel Car Company, to assist in the inspection of the material while building. In this way many men became familiar with the smallest details of each and every part. The expedition demanded experienced men to run the locomotives and operate the trains on the railways of France. About 100 skilled mechanics were furnished from the United States Naval Training Station, Great Lakes, and several engineers, firemen, and others to make up train crews volunteered for enrollment upon being informed of the country's need for them.

Every war seems to possess some creditable record for speed. During the Spanish-American War all records were broken by the *Oregon* in steaming from the Pacific coast to Cuba. In the

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to qualify as sharpshooter or higher. Have daily instruction in signalling, including semaphore, blinker, buzzer and radio, if possible.

"Every night (except Sunday) have instruction. Intensify the work and eliminate all men unable or not disposed to undergo incessant work.

"Make daily report of range practice and of the other instruction to the Director of Gunnery Exercises and Engineering Performances.

"*This is for most important and desirable duty.*"

Boer War the famous gun "Long Cecil" was built at Kimberly in 23 days. In this war the first 14-inch naval railway mount was completed in 72 days from the award of the contract, or 120 days from the commencement of the first preliminary designs.

From the moment that the bids were accepted and contracts awarded the fabrication of the material moved rapidly forward. The construction of the girders by the American Bridge Company progressed so rapidly that they were delivered to the Eddystone shops of the Baldwin Locomotive Works in less time than had been thought possible. When they were delivered, the shop superintendent was fully prepared to assemble. The trucks, air compressors, winches, castings, and other fittings had been obtained in some manner and assembled at Eddystone, so that when the girders came in, no time was lost in attaching the deck lugs, fitting the elevating mechanisms, placing the girder on its trucks, adjusting the gun slide and putting the gun in place. The Naval Gun Factory furnished for each mount all of the strictly ordnance parts; *i. e.*, the gun, slide, deck lugs, elevating gear, breech mechanism, loading device, etc. And in performing this vast amount of work they were always a few days ahead of time. The first mount was scheduled for delivery on May 15, 1918. Mr. S. M. Vauclain, senior vice president of the Baldwin Locomotive Works, made the schedule out himself only to have it broken, for the first mount was completed at the Eddystone plant of the Baldwin Locomotive Works on the morning of April 25, 1918. The last mount was scheduled for June 15, but was completed on May 25.

There were no changes in the design to delay construction. Plates for the girders were rolled at Pittsburgh and rushed in special cars to the American Bridge Company's fabricating plant at Pencoyd, Pa. The material furnished by the Washington Naval Gun Factory was sent to Eddystone by motor trucks, and, in fact, every conceivable method of transportation was used in seeing that the material reached the Baldwin Locomotive Works shops on time. Notwithstanding bad traffic conditions and some of the coldest weather and heaviest snow falls that the Eastern States had experienced in many years, the material reached there, and on time.

While one end of the Baldwin Locomotive Works shop was engaged in erecting the gun cars, the other end was erecting the

locomotives for the expedition. At the plants of the Standard Steel Car Company located in various parts of the country, the building of the auxiliary cars was pushed so that they too were finished in advance of the delivery schedule. In spite of a severe fire and a young cyclone which destroyed a considerable portion of the Hammond, Indiana, shops the auxiliary cars were completed by June 1.

Among the problems encountered in connection with the naval railway batteries was the field available in the United States for proving such a long-range engine of war. The navy had no suitable proving ground, for at Indian Head the range was limited to a maximum of about 15,000 yards. There was only one proving ground in the United States where the firings could be safely conducted. That was at the Army Proving Ground, Sandy Hook, N. J. The only course open, therefore, was to appeal to the army for permission to conduct the proof of the first mount at Sandy Hook.

Permission to test the 14-inch gun and mount at Sandy Hook was granted, and preparations were made to carry out the work.

The men who were on the station for instruction built a special siding and installed the first pit foundation upon which to test the gun. These men at Sandy Hook had become almost expert in laying new track and making track repairs, for it happened that about two weeks before the first gun was expected to be ready for test, a severe storm raged for several days which caused such a violent sea to beat in on the sandy beach that the government track connecting the proving ground with the Central Railroad of New Jersey at Highlands was badly washed out in many places, and, in one place, was entirely destroyed for a distance of about 1000 yards. Sandy Hook, instead of being on a peninsula, for a short time was on an island. The blue-jackets on the station assisted the army materially in making repairs to this government line. They realized that the track had to be renewed in as short a time as possible if the railway mount was not to be delayed in arriving at Sandy Hook.

Arrangements were made with the Philadelphia and Reading Railroad and the Central Railroad of New Jersey to move the mount from Eddystone to Sandy Hook by a special train. Up to

this point everything in connection with the project of sending long-range guns abroad had been kept confidential, but on this trip, where it was necessary to pass through Philadelphia and other cities, the nature of the undertaking began to become public. It was impossible to transport such a huge device over the railways without attracting attention. The gun and its mount were covered over as well as possible, and camouflaged in such a manner that at least the details could not be discerned by observers who might be along the tracks while the train was under way.

The movement of this first gun from Eddystone and its test at Sandy Hook were among the most important events in the life of the naval railway batteries, for the entire enterprise depended upon satisfactory results, both in transportation and in firing.

The officials of the Reading Railroad were most courteous in cooperating with the navy in this shipment by special train. They selected one of their most able train crews for the journey. Coaches and a special car were attached to the train, in order that meals could be served and every one made comfortable during the trip.

Rear Admiral Plunkett, Captain T. A. Kearney, assistant chief of the Bureau of Ordnance, most of the officers who were to go abroad with the batteries, and several others from the Bureau of Ordnance accompanied the train to observe its performance in transit. Undoubtedly, in handling the movement of this gun car the Reading and Jersey Central Railroads successfully handled over their lines the heaviest piece of rolling stock ever transported over the railways in the United States, and for that matter over any railway in the world. The mount as it stood when it made this trip weighed over 250 tons; the load between the rails and wheels of each axle on the rear truck being 39,630 pounds, while on the front truck the reaction on each axle was 50,330 pounds.

There had been considerable anxiety concerning these axle loads, for they were criticised by officials at home, and the French authorities were doubtful if it were safe to transport such a concentrated weight over the French railways. The navy's engineers were confident that the axle loads would not prove excessive, but, in view of the many criticisms, there was the possibility of being mistaken, until the actual tests had shown everything to be satisfactory.

On the morning of April 25, 1918, when the Baldwin Locomotive Works, with one of their own engines, hauled Railway Mount No. 141 out of their Eddystone plant and turned it over to the Reading Railway for the remainder of the journey, that company had completed in the remarkable time of 72 days the greatest engine of land warfare that had been produced in the United States. It was a most patriotic sight, and it was with great pride that the Reading engineer opened the throttle to set the train in motion. It required as much effort to start the gun car as if the engine were hauling a heavy freight, but when once in motion the train rolled along easily and smoothly. The gun car took the curves with no difficulty and passed over the switches as nicely as any Pullman, and every one was elated. Aside from frequent stops made necessary, due to overheating of the journals, which caused hot-box troubles, the facility with which the mount could be handled on the railways was most satisfactory. It was believed that the bearing troubles were only temporary, and to redesign the trucks to lessen the axle loads was out of the question on account of the time necessary to make such alterations.

Highlands, N. J., the station at which transfer was made from the Central Railroad of New Jersey to the government line of about seven miles running into Sandy Hook, was reached at 3 a. m. on the morning of April 27. Upon reaching this station it was decided to inspect the new track that had been put in. The work had not been entirely finished, although the men had worked until late the night before. No heavy trains had passed over the track, and when inspected by the light of a lantern it was believed that the new fill would never support the heavy gun mount while making passage over it. Discouragement prevailed, but Colonel Philips, U. S. A., commanding officer of the Sandy Hook Proving Ground, with the party, again went over the track in daylight, and it was decided to go ahead rather than to wait several days for further track repairs. A government locomotive hooked up to the train and went ahead at slow speed only to find that there was no cause whatever for anxiety; there was no evidence of track failure at any point all the way to Sandy Hook. As far as the question of axle loads or the mobile qualities of the mount were concerned, the Bureau of Ordnance was certain that during this trip from Eddystone to Sandy Hook, the United States naval railway battery mount had been subjected to extreme conditions pre-

vailing in the United States, and it was certain that no troubles would be encountered while moving from place to place along the firing lines in France.

The mount was subjected to firing tests on April 30. The Bureau of Ordnance arranged for a special train from Washington to Sandy Hook to bring representatives of the United States Navy, the United States Army, and various naval and military officers of the nations associated with the United States in the war to witness the tests. Upon the arrival of the train the party proceeded to inspect the various details of this new shore mounting for a large-caliber naval gun; all seemed pleased with its fine appearance and especially with its simplicity and with the ease and rapidity with which the various operations were accomplished. The mount was first run over the foundation, jacked up, and the transom bed plate adjusted to take the reactions when firing at high angles. The gun was loaded and laid at 25° elevation. The primer was inserted and the firing wires connecting with the hand-operated magneto were led out to a distance of about 100 yards. A large party of army officers and men from Fort Hancock had assembled to witness this first shot from the 14-inch gun. There was more or less suspense, for every one appreciated that, when the firing circuit was energized, the 484 pounds of powder would exert its force on the 1400-pound projectile with such an amount of energy that it seemed none too certain that everything would function perfectly. Many comments were heard to the effect that when the first shot was fired the entire gun car would capsize; that the gun-pit foundation would be entirely wrecked, and, in the minds of a few who were waiting to see this first shot, there was a great deal of doubt as to its being a successful piece of ordnance.

While the audience held their fingers in their ears, Rear Admiral Earle grasped the handle of the magneto and operated the lever to fire the gun. Nothing happened! There was a misfire, and the gun did not go off! It was found that one of the firing wires had become disconnected and when the admiral operated the magneto no current had reached the primer. The firing wire was again secured to the firing lock and this time when the chief of bureau pressed the lever there was no misfire, and to the relief of every one, when the dust cleared away, the mount was still there.

There was a grand rush to the gun to see how it had functioned. All the parts were carefully gone over, and there was no evidence of failure of any part. The gun returned to battery properly, the car withstood the firing reaction, and the gun-pit foundation, which had been imbedded in sand, stood up wonderfully. It was apparent to all that on this first shot all the dreams of the Bureau of Ordnance and of the Naval Gun Factory designers had been realized. Firings were continued from the pit foundation at elevations of 25° and 45°. Then the mount was removed from the pit and fired from the rails at elevations of 10° and 15°. On every test the railway mount performed as predicted by its designers, and it was apparent to all that it was a decided success.

The special train returned to Washington the same evening and every one aboard was thrilled with the events of the day. Rear Admiral Earle was congratulated by every one present.[5]

[5] "AMBASSADE"
DE
FRANCE
ATTACHÉ NAVAL. WASHINGTON, May 2, 1918.
PERSONAL.

MY DEAR ADMIRAL EARLE:

The two French artillery officers sent to Sandy Hook to witness the trials of the 14-inch guns on rails, at which I was unhappily unable to assist on account of Admiral Crasset's presence in Washington, have reported to me the complete success with which they have met. They consider that the Bureau of Ordnance has accomplished a marvellous feat in the rapid construction of these trucks and that the trials have been entirely satisfactory; there is no doubt that they mark a considerable progress and will prove to be a most remarkable weapon for long-range bombardments.

Will you accept my best thanks for having allowed us to be present at these interesting experiments and also for the courtesies extended to the French officers.

Believe me, my dear Admiral Earle,

Yours very sincerely,
(Signed) B. A. BLAUPRE.

BRITISH WAR MISSION, MUNSEY BUILDING
WASHINGTON, D. C., May 1, 1918.

DEAR EARLE:

I wonder if you have got a spare copy of the particulars (two blueprints) of the 14-inch mounting, which you showed me yesterday, that you could let me have?

I am sure my people in England would be immensely interested, and I should like to send them as much information as I could with my reports

Rear Admiral C. P. Plunkett remained at Sandy Hook to make arrangements for the return of the gun to Eddystone. To him, it seemed almost as though he were on the Western Front, for between daylight and dark on April 30 he had maneuvered the mount into a firing position over the pit, fired several shots, then removed the gun from the pit, fired several more shots, then hooked up an engine and was withdrawing from the scene of "battle." The train was assembled the same evening, and during the night Railway Mount No. 1 was en route to Eddystone for dismantling preparatory to shipment abroad.

All doubt concerning the proper functioning of these huge pieces of artillery having been dispelled, Admiral Sims was informed of the results of the tests, and was requested to confer with the authorities abroad to determine a port of debarkation, in order that overseas shipments could be arranged. Material for the naval railway batteries at this time was being delivered very rapidly, and it was continually piling up in the Philadelphia navy yard. By May 2, when the first mount had been returned to Eddystone for dismantling, Mount No. 2, had been completed, and the enthusiasm that prevailed in the Baldwin shops when they learned of the satisfactory operation of their first gun may be realized from Mr. Vauclain's letter to Admiral Earle.[6]

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of the trials yesterday. If you have drawings showing the general arrangements of the elevating, traversing, and recoil arrangements separately, they would also be much appreciated.

I must again congratulate you, and your Department most warmly, not only on the complete success of the trials but on the extraordinary quick time in which you have got these mountings out—not to mention the excellence of your arrangements for the comfort of the spectators.

Yours very sincerely,
(Signed) John Headlam.

Rear Admiral Earle,
Chief of Naval Ordnance,
State, War and Navy Building,
Washington, D. C.

[6] The Baldwin Locomotive Works, Philadelphia, Penna.
Washington, May 13, 1918.

*Rear Admiral Ralph Earle, U. S. Navy, Chief, Bureau of Ordnance, Navy Department, Washington, D. C.*

My dear Admiral Earle:

I spent yesterday (Sunday) morning in the Baldwin Locomotive Works at Eddystone, Pennsylvania, and am glad to advise you that the five (5)

During the construction period of all this equipment the contractors and all persons having to do with its building were spurred in their efforts by the repeated accounts of the German long-range guns firing into Paris, and the reports of the telling effect of the German long-range guns all along the front. The "German Berthas" were doing considerable damage to material and were having a serious influence on the morale of the French people. The navy's foresight in preparing the expedition for foreign service was appreciated during May, for it was at this time that the Germans were making rapid advances, and the channel ports were threatened. Through the office of Naval Intelligence information was received that 380-millimeter guns originally intended for the *Hindenburg* had been mounted by the Germans, one near Lille, to fire upon Dunkirk; one at St. Hilaire-le-Grand, to fire upon Chalons-sur-Marne; the third near Pont-à-Mousson, to fire on Nancy, and four more had been mounted two months before in a wood four kilometers above Crepy, Laon. It was definitely established that 16 heavy naval guns had left Kiel towards the end of May for Belgium. They were believed to be 305-millimeter guns, manned by naval personnel, and were probably attached to the Marine-Sonder-Kommando.

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large gun mounts will be finished complete in every respect ready for shipment Saturday, May 18, or about two (2) weeks ahead of time originally contemplated.

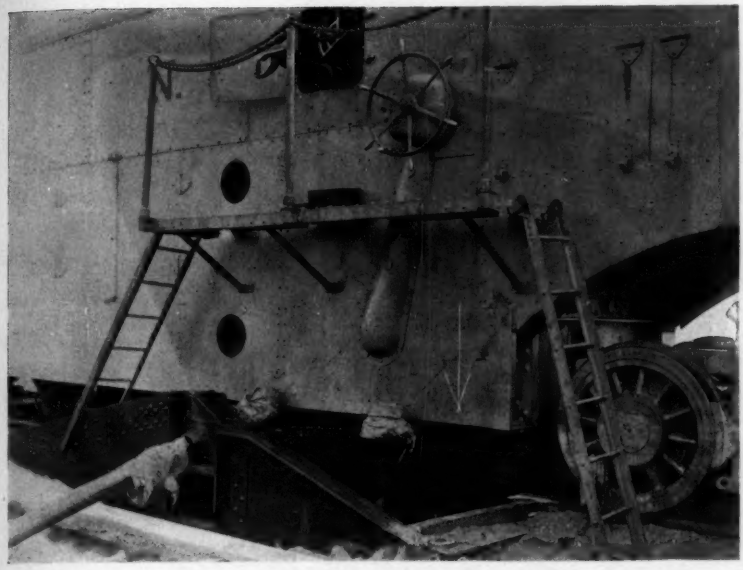
Our people at the works are most enthusiastic over the standard of workmanship on the parts furnished by the Washington navy yard to go on these mounts. The last piece arrived at 6.40 Saturday evening last.

This has been a most delightful task. The designs were thoroughly worked out before hand. Your Department knew exactly what it wanted. The parts furnished by the navy yard came through on time and in the best possible shape. Not a single difficulty was experienced and I trust that the service rendered by the Baldwin Locomotive Works may prove satisfactory.

Work has been begun on the three (3) additional mounts and a schedule of delivery will be sent you at an early date.

Very truly yours,

S. M. Vauclain,
Senior Vice President,
Baldwin Locomotive Works.



THE GUN CAR RESTING ON PIT FOUNDATION.

FLAT CAR THROWN ON TOP OF AN ADJACENT CAR BY ONE SHOT FROM NO. 1 GUN OF THE U. S. NAVAL RAILWAY BATTERIES FIRING AT LAON, FRANCE.

The High Commission of the French Republic in the United States appealed to our War Department for assistance in early deliveries of long-range artillery.[1]

The Navy Bureau of Ordnance had, early in the war, furnished to the Ordnance Department of the army a considerable number of naval guns varying in caliber from 3-inch to 12-inch, and, by special arrangements, a number of 14-inch 50-caliber guns subsequently were released by the navy for their use during the summer of 1918. While effort was made by the army to place these guns in operation in France, so far as is reported, only a few of the minor calibers were ever shipped abroad, and no successful mounts were fabricated for the larger guns in time to permit them actually to take part in the war. After the Sandy Hook firing of the naval mount, the Ordnance Department of the United States Army requested the Navy Bureau of Ordnance to build three similar mounts for them. These three were completed the latter part of August, and, the rapidity of their construction being satisfactory to the army officials, they duplicated their order for an additional three which were finished by October 1.

As mentioned in the beginning of this article, the original tactical use that led to the building of these mounts was to answer the long-range German bombardments of Dunkirk. By May 15, with the completion of the entire project actually in sight, and at most one or two weeks' distance, conditions in France had changed entirely. The threatening of the channel ports made it impossible to risk shipment to the British transportation centers. It was decided to communicate with General Pershing to determine if the guns could be of use to the American Army. On May 23 General Pershing showed his appreciation of what the navy had accomplished by requesting shipment of the guns, railway mounts, and

[1] Extract from the letter of the High Commissioner of the French Republic in the United States, dated May 30, 1918:

"On account of the present circumstances which render more and more urgent the necessity of a long-range artillery, able to reciprocate the firing of similar guns to those which fire actually on Paris, the organization on 340-millimeter carriages of 14-inch guns already existing, or the manufacture of which is under consideration, as expressed in my letter of the 14th instant, takes every day an increased importance."

(Signed) High Commissioner of
the French Republic.

rolling stock to France immediately. St. Nazaire was assigned as the port of debarkation, and the one requirement made by the army was that the transfer to France should be accomplished without demand on army tonnage.

Pershing's word filled the personnel of the naval railway batteries with enthusiasm. Arrangements were immediately made with the Bureau of Supplies and Accounts for the necessary shipping.[8]

The detail of men at the Naval Gun Factory, the Naval Proving Ground, Indian Head, Md., and the various inspection districts were ordered, by telegraph, to assemble in the navy yard, Philadelphia, preparatory to proceeding overseas.

The first draft of 250 men and eight officers, Commander Garret L. Schuyler, U. S. Navy, in charge, sailed for Brest on May 26, 1918, arriving at St. Nazaire on June 10. The second draft of 207 men and six officers, with Lieut. Commander J. W. Bunkley,

[8] To: The Bureau of Ordnance.

1. In accordance with cablegram, War Department, copy of which has been handed Lieut. Commander Bye this date, instructions have been issued by the navy to ship material for the 14-inch new railway battery by the first available naval transport.

2. It is expected that part of this material will be loaded on the U. S. S. *Bath,* sailing for St. Nazaire direct; also other shipments on the U. S. S. *Newport News,* and on the U. S. S. *Texel,* sailing direct.

3. It is requested that the bureau issue any instructions which they may consider necessary to safeguard the handling and shipment of this material to the Bureau of Supplies and Accounts, with a request that they immediately inform their representatives at Philadelphia to exercise proper precautions in the loading of these vessels.

4. It is also requested that the allowance of ammunition be divided among the above-named vessels and shipped at the same time as the material.

5. A large part of the personnel will precede the material with instructions to make all necessary arrangements for the proper reception and erection of the bureau's material on the other side and for such temporary or permanent storage of the ammunition allowance and reserve as may be determined from time to time.

6. Any suggestions which the bureau may have to make in regard to the handling of this whole situation are earnestly requested, in order that no stone may be left unturned to insure the safety of this material from the time of departure until active operations begin, and as far as possible, thereafter.

(Signed) C. P. Plunkett.

U. S. Navy, in charge, sailed on June 15, arriving at St. Nazaire on the 29th. Commander Schuyler commanded the naval detachment in France until the arrival of Captain C. P. Plunkett on July 16.

Besides the usual difficulties connected with the shipment of such heavy material, the journey to France at this particular time was extremely dangerous. It was during this same interval that German seagoing submarines were operating off our coast, laying mines and sinking numerous vessels by gun fire. Every one will recall how persistent these pirates of the sea were in their activities. How they appeared one morning so close in shore off Cape Cod, that, while sinking a number of innocent barges by gun fire, the shells actually fell on the beach. The *San Diego* was sunk by a torpedo from one of these submarines or by one of the mines laid by them, and even the U. S. S. *Texel,* which had been designated to carry a cargo of material for the naval railway batteries, was sunk on June 2 while nearing port, so that another vessel had to be substituted. The first shipment from Philadelphia was actually made on the U. S. S. *Newport News* on June 20, and shipments followed on July 4 by two steamers, the *Bath* and *Pensacola.* The *Newport News* arrived safely at St. Nazaire on July 8, while the two latter ships required until July 21 and July 27, respectively. Other shipments followed on the *Malang* and *Rappahannock,* which arrived at St. Nazaire on August 11 and 15.

During the entire construction period of the material for the railway batteries the work was supervised by Lieut. Commander D. C. Buell, U. S. N. R. F. It happened that Mr. Buell was visiting in Washington at the time the contracts were being awarded to the Baldwin Locomotive Works and the Standard Steel Car Company. He appeared in the Bureau of Ordnance one morning and expressed a desire to assist in war work. Mr. Buell was known to be an excellent railroad man, so he was immediately enrolled as a lieutenant and assigned as a special inspector to handle all the material for the expedition. He performed this work most ably, and upon its completion he was sent to St. Nazaire to assist with the work of erection in France, where he remained until the assembly was completed.

Lieut. Commander George T. Ladd, U. S. N. R. F., from Pittsburgh, Pa., gave up his own business and volunteered to take up

the inspection work while Mr. Buell was abroad. Lieut. Commander Ladd was familiar with the entire project, for he had assisted Mr. Buell for several weeks during the busiest days as a sub-inspector of ordnance. He was a very competent officer, for under his supervision six railway mounts similar to those with the United States naval railway batteries were built for the Ordnance Department of the army, and besides, he handled the inspection of a large contract for 7-inch tractor mounts that were building for the United States Marine Corps. Many men of the type of Ladd and Buell volunteered their services to the government during the war, and it is hoped that *their* assistance was appreciated by others as much as the navy appreciated the services of these two men.

Lieut. Commander Buell arrived in St. Nazaire on June 20. At this time a majority of the preliminary arrangements for the expedition in France had been completed by Commander Schuyler. A site for barracks had been obtained and the construction of the barracks was well under way. Arrangements had been made for mounting the guns in a French shop that was in use by the 19th Engineers, U. S. A. Arrangements had been made with the 19th Engineers for the use of space in their railroad yards for storage and construction purposes. Permission had been granted by them for the use of as much scrap lumber, from locomotive packing cases, as was necessary to complete the barracks. Conferences had been held regarding the movement of the guns over various railroad lines. Many other details were being worked out concerning the general conduct of the expedition after the assembly had been completed.

The 19th Engineers, all railroad shop men in civil life, were very friendly and willing to co-operate in every manner. Commander F. P. Baldwin, U. S. N., naval port officer at St. Nazaire, took keen interest in the work and assisted in every possible manner.

Conditions at the port were not entirely satisfactory. There was shortage of labor and congestion in the yards, due to the vast amount of material arriving from the States.

The first shipment of the navy material was not expected to arrive for at least two weeks, so it was decided to distribute as many navy men as possible about the port at places where they would be learning the yards, the shops and, at the same time, ren-

dering service to the army. With this in view, an experienced round-house foreman and 15 mechanics were detailed to the 67th Engineers; 50 skilled mechanics to the 19th Engineers, and three switching crews, four engineers and firemen were detailed to work with the army in the yard. All of these men were very badly needed, were eagerly accepted and they made good in every particular. Rear Admiral Plunkett was especially anxious to assist the French and the Americans in every way possible, for he appreciated that by so doing they would reciprocate in granting many favors to the navy while their material was being assembled. As opportunity offered, several trips were made by automobile to points on the railroads out of St. Nazaire to inspect the road bed and bridges, with reference to their capacity for carrying the naval mount safely. These inspections convinced the officers that the road bed was perfectly safe for the guns, and that all the main line bridges were safe for moving at slow speed and, in most cases, were safe for moving at any reasonable speed.

Captain Debonett, a French artillery constructor, who, in civil life, was a bridge engineer, visited St. Nazaire and went into detail in regard to the bridges, axle loads, etc., with the result that he was absolutely convinced of the safe carrying capacity of the French bridges for the naval expedition; but he was somewhat doubtful as to the track holding up under the weight of the gun. So with absolute confidence, on the part of the naval officers, that the French track was entirely adequate, and with full confidence in the bridges, on the part of Captain Debonett, it was decided that there would be no difficulty in moving the guns almost anywhere in France.

When the *Newport News* arrived, the naval battery was ready and waiting to proceed with the assembly work. The army's experience had demonstrated that in all cases it was advisable not to start actual erection until all material necessary for a complete unit was actually on hand and in the yard. This proved to be the best practice with the navy material as well, for in making hasty shipments from the United States it was impossible to separate the enormous number of parts into those pertaining to individual trains; and, consequently, at St. Nazaire, when the first ship arrived, it was found that necessary component parts were missing and nothing was to be gained by commencing the erection of material before all had reached port and been unloaded.

The locomotive and car erection began on July 20. The assembly of the first gun was begun on July 26, and the first train was completed and ready to leave St. Nazaire on August 11.

In all the assembly work the men were seriously handicapped for, in some unexplainable manner, all blueprints were missing. The resourcefulness of the American blue-jacket was here again made evident, for those who had been detailed to assist in the inspection work at the Baldwin Locomotive Works and the Standard Steel Car Company had kept individual notebooks. They had taken them to France, and with the sketches that these notebooks contained many an unknown step in the putting together of the gun cars and the various other parts was accomplished.

It is needless to state that the work at St. Nazaire was done under high pressure. Admiral Plunkett was continually receiving urgent requests to expedite the work and get his guns to the front.

Orderly procedure in the work of erection as intended in the beginning was considerably interrupted, in order to comply with these urgent demands. The original schedule was rearranged and special effort was made on the first two trains which made them available for leaving St. Nazaire on August 18 and 19, each with 100 rounds of ammunition per gun.

The manner in which Rear Admiral Plunkett and his men overcame all the difficulties of the complex assembly work did credit to the best navy traditions. Seamen all, they worked till they dropped exhausted, and their night and long day hours of labor were continuous until the guns left for the front.[9]

[9] Extract from Lieut. Commander Buell's letter to Captain Kearney, dated 8/28/18:

"We have had no construction difficulties of any kind, other than lack of material when we needed it. The ships were all loaded upside down, and we were not able to get started on the construction job until the last of the stuff on the second ship was unloaded and on the ground in the yard. From that time on we have made good speed. . . . .

"On the selection of men I was very fortunate. There has been only one thing in the whole project that we were not able to find a competent man to handle, and that was the job of putting the lagging on locomotive boilers. We borrowed a man from the army and made out all right. I thought I was out of luck for a man to do lettering and stenciling of cars, but on combing the outfit I found three experienced lettering and sign painting men and had no further trouble on that score."

The urgent need for the first two guns at the front was in order that they might perform a special mission of firing upon the German long-range gun which, at that time, was bombarding Paris. Admiral Plunkett devoted special attention to the assembly of these two mounts and took personal charge when they moved from St. Nazaire.[10]

The first train, after being inspected on August 17, 1918, by the Assistant Secretary of the Navy, Franklin D. Roosevelt, left St. Nazaire on August 18, 1918, followed by the second train on Monday morning, August 19. The schedule called for the train to pass over the Orleans, État and the Nord systems. The total distance was more than 350 miles, and the destination Helles-Mouchy. A speed of six miles per hour was set, for it was considered that, as the material was all new and there was some question about the weights involved and the strength of the bridges, a speed greater than this in the beginning might have involved some questions which it was desired to avoid until it was proven that the French road beds and the naval railway rolling stock were both capable of successfully meeting all situations.[11]

[10] Extract from Naval Railway Battery Report on Material for week ending August 17, 1918:

"I will proceed with the first train to the front to-morrow morning, establishing a "garage" on the railroad near Creil. The French naval batteries were already there when I visited them this week. It is about 45 minutes automobile run from La Morlaye, a French General Reserve Headquarters. The gun positions were determined during my recent visit there, but a new position, I understand, has been selected and I will inspect them on arrival of the first train.

"In connection with the anxiety of the axle loads involved in our gun mount, it may be of interest for you to know that we have tried all the tracks in St. Nazaire, culminating in a passage over a temporary crib work which rather shocked the railroad people, but demonstrated that this mount of ours negotiates things that were never contemplated in its original design.

"(Signed) C. P. Plunkett."

[11] Extract from Admiral Plunkett's letter to Commander U. S. Naval Forces Operating in European waters, dated August 27, 1918:

"Both guns arrived at Helles-Mouchy ready for action, but upon arrival a change in the original plan for the guns was made by the chief of French reserve artillery and I was requested to take one of the guns to Haussimont, the A. E. F. reserve artillery base (and the base to which the remaining guns will be sent in accordance with request from commanding general,

This first trip in France was a memorable occasion, for many French cities, including Paris, were passed through and the French people on seeing that large American engines of war were actually in France, were happy and encouraged. When passing many troop trains loaded with American soldiers cheer after cheer was given. On all occasions as soon as the gun was seen crowds gathered and went wild with excitement. Word of its coming was flashed ahead of the train so that at many stations people had gathered in curiosity and many had come with flowers and wreaths to decorate the big weapon. Many were surprised and agreeably startled when they found that the wreaths were too small for this gun and would not pass over the muzzle. Information concerning

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A. E. F.). The situation, then, is that we have one gun at Helles-Mouchy which can be used for operation in the original sector as contemplated by the French and the other gun at Haussimont, which will conduct some trial firing at Mailly and then be available for service as may be requested by reserve artillery command. I shall proceed to St. Nazaire at the end of the week ending August 31, for the purpose of conducting the movement of the remaining guns, together with the supplies and material, to Haussimont.

"It has been a matter of great satisfaction that we have fully demonstrated to the French authorities that these guns and mounts can be moved over the standard railway tracks and bridges at speeds which are safe, and without damage to the right of way. I was always of the opinion that would be the case, but in some unaccountable manner, before my arrival in France, this question of the safe transportation of the guns, as mounted, over the French railroads had become a matter of official correspondence between our army and the French military and railway authorities. As soon as I could locate all the threads of the matter I personally took the matter up with the French authorities, and, as a result, have succeeded in carrying out movement of two guns to a designated position 350 miles from St. Nazaire, and have further transported one gun immediately from behind the Allied line from Creil to Chateau-Thierry and along the Marne to Epernay and thence to reserve artillery base, A. E. F., Haussimont. It has been a most valuable experience for our personnel, and has given us an opportunity to breathe the atmosphere surrounding that part of the front where our own naval forces made their famous stand, and also to move over lines which were once destroyed and since rebuilt. In fact, as I write this report the movement of the train is held up, pending the ceasing of enemy operations, either by gun fire or bombing, in the immediate vicinity of the train. All of this is of the greatest value in preparing young material for active work, and I shall endeavor to take the remaining guns over the same route as the first gun, in order to give them the same opportunity of observation and experience."

the guns spread over France, and undoubtedly reached the Germans, for when Battery No. 1 arrived at Helles-Mouchy at 8.30 p. m., August 23, and Battery No. 2 on August 24, the German long-range gun had been withdrawn. "The bird had flown." The bombardments of Paris had ceased before the naval guns had taken position to fire a single shot against them.

The cessation of bombardments of Paris gave the naval railway batteries a few days in which there was no immediate mission for the guns. It was decided to fire a few rounds to demonstrate to the foreign officials what sort of duty these guns were capable of performing, and to test out the assembly work that had been done at St. Nazaire. Battery No. 1 was chosen for the test firing and left Helles-Mouchy at 6 a. m., August 27, from where it proceeded to the French proving ground at Nuisemont on August 28. Battery No. 2 in the meantime proceeded to Rethondes in the forest of Compiègne to fire upon an ammunition dump at Tergnier.

The proving ground test of Battery No. 1 at Nuisemont was most encouraging. The pit was installed in time so that on September 2 four rounds at reduced velocity and four rounds with full charges were fired. The territory available was not sufficient to allow firing the naval guns at their maximum elevation. The gun was laid for a range of 29,000 yards. The shots actually fell at 29,000, 29,300, 29,000 and 28,900, respectively. It is needless to say that the French were very much pleased with this firing, for the low dispersion was declared by them to be most remarkable, and they refused to allow further expenditure of ammunition for demonstration purposes. They concluded that the guns were perfect in all respects, and that the proper place to conduct future firings for demonstration or other purposes was at the Front, smashing German positions.

Meanwhile Battery No. 2 had laid track and prepared the firing position at Rethondes under direction of the 10th French Army. On September 6, 1918, after firing only one shot, orders were received to cease firing for the Allies had captured the village of Tergnier.[11] By a peculiar coincidence it happened that Bat-

[11] Extract from Schuyler's letter of Sept. 24/18:

"Finally we were all ready to fire at Tergnier, and the spotting plane was up, but could not observe and failed to give us one signal, and then ran out of gasoline, and anyhow the French troops at the time were capturing

tery No. 2, when firing this first shot from the naval railway battery in France against the Germans, occupied the same position as occupied by the train carrying General Foch and his staff at the time the armistice was signed later on November 11, 1918.

There was continuous demand for the American naval guns; so, as soon as they had concluded their firing at one point they received orders to proceed to another. Battery No. 1 went from

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the town. As the gun was loaded, however, they let us fire it. The sand packing behind the back timbers had not been very well done in this pit, so it came back one-half inch. This would not have been serious, but we profited by it in subsequent installations. We never learned where the shot fell, but I think it went its 41,000 yards all right, and that it was the longest range shot that had so far been fired at the Germans.

"Then they moved us up the track at night to a place called Fontenoy. They have lots of air raids and bomb the tracks, so that at least every 100 yards has at some time been hit and repaired. There was an air raid just before we started which cut all the telephone lines, and we had to crawl along slowly to see whether the track had been cut, and to get permission from each station to proceed to the next. Fontenoy was in the hands of the Germans during the last push. Our target there was an ammunition dump at about 38,600 yards. The first time we fired we got off two rounds, but the plane could not see them. There were woods near the target, so we changed the range of the second 1000 yards to get it out in the open. Still the aviator could not see it and he ran out of gasoline. We had to wait for another occasion because of bad weather, but then got hurry-up orders to fire 10 rounds without observation. We do not know how we came out on this, but they could hear us all over the front. Four of the observation balloons in front of us were burned down in two days. They could not have seen our shots anyway, however.

"The next day we tried an observation shot again and could pick up nothing for the first two rounds. The aviator spotted from a height of 6000 meters and had a gale of about 90 kilometers an hour, blowing him towards the German line. He got his hand and his face frozen. On the third round, he saw our burst about 1000 yards to the left. I had jacked over about 600 yards when we got the signal to fire again, so let it go at that, and was given OK in direction, but 1300 yards over. We were firing purposely 1000 yards beyond to register in a clear spot, if possible. On the next round, I brought it down 1300 yards and left the direction unchanged. He reported that he could not see the bursts well at all from this height, but is sure that we hit some ammunition on the third round. We were told to finish out our 10 rounds, so we shot the last seven rapidly. We knew we were on in direction and were 1300 yards over while intending to be 1000 over, so we felt quite pleased with the probable accuracy of the estimated range of the remainder. The last seven shots (six intervals) we got off in 25 minutes."

the French proving ground to Soissons, where, on September 11, position was taken near St. Christophe Cemetery while Battery No. 2 proceeded to Fontenoy-Ambleny.

While these first two batteries were actually operating, work was continuing at St. Nazaire on the remaining three. Train No. 4 left St. Nazaire for Haussimont (Marne) on September 15, 1918, and was followed by Trains No. 3 and No. 5 on September 16 and 17. They arrived at the railroad artillery reserve base, Haussimont, on September 23, 24 and 26, respectively.

Some delay in the firings of Batteries Nos. 1 and 2 occurred, owing to weather conditions preventing observation by aeroplane or by observation balloon. It was decided to proceed without observation, so on September 14, Battery No. 2 fired 10 rounds at an ammunition dump in Besny-Loisy, which is just west of Laon. Battery No. 1 on September 28 fired its first shots into the German lines by putting 47 rounds over between the hours of 1 and 5.30 p. m., at a range of 34,320 yards. The target was the railroad yard. The retreat of the German forces from Laon began on September 28 while the U. S. Navy long-range bombardments were in progress. Battery No. 1 continued firing until dark, when it was necessary to cease on account of the flashes of the gun being easily seen by the enemy. Enemy bombing operations in the vicinity of Batteries Nos. 1 and 2 were of frequent occurrence. They were successful as far as French material was concerned, but no damage was done to the United States guns.

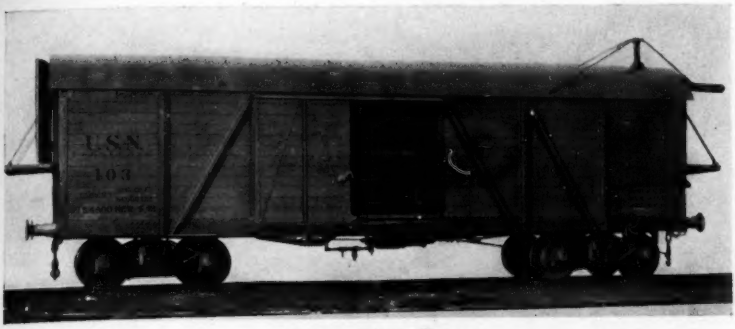
Battery No. 2 again fired 12 rounds into Besny-Loisy on September 15, making a total of 22 rounds after which the gun was withdrawn and taken on October 6 to Flavy-le-Martel, where they arrived on October 8. Battery No. 1 remained at Soissons until October 24, firing in all a total of 199 rounds from the same pit foundation. One hundred and twelve rounds were fired at the railroad yards to the northwest of Laon on September 28, 30, and October 2. On October 2 the target was shifted to a point northeast of Laon, where the remaining 87 rounds were fired at ranges varying from 38,000 to 36,660 yards. In all these firings from Battery No. 1, observation of the fall of only 23 shots was possible.

Battery No. 1 had innumerable interesting experiences and narrow escapes while in action at this point. Every one in the vicinity was most anxious to visit the gun, and they gasped in

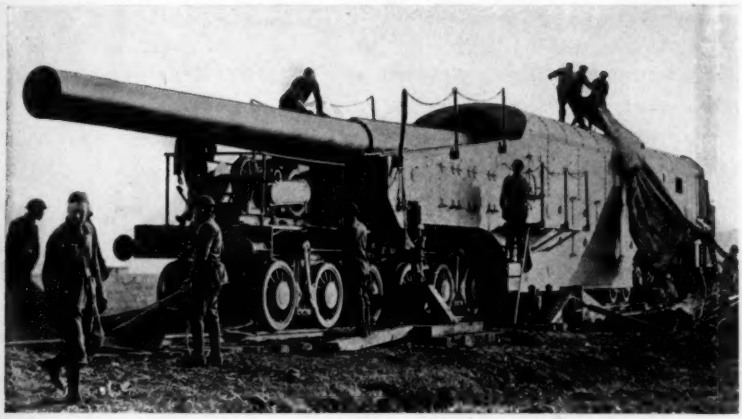
wonder as the weapon hurled the enormous projectiles from its muzzle toward the retreating Germans. French and American nurses from a hospital at Villa-Cotterets took particular delight in going to the front to witness the action of the gun, because the Germans were hurling bombs upon their hospital every night, and it must have been very gratifying to them to witness the retaliation that was being administered by the American blue-jackets. Officers from the Allied armies repeatedly inspected the mount and observed its action. Military visitors were so numerous that the gun's crew was frequently interfered with, and it was necessary to hold back the more curious by putting up a rope fence. Congressmen who were in France to observe the operations of the American Army also took the opportunity to visit Battery No. 1, and in one instance one of these gentlemen wrote his name upon the projectile before it was hurled against the Germans.

Shells from the enemy were continually passing over head, and frequently falling in the vicinity of the battery. On October 5, at about 4.30 p. m., an enemy shell burst directly overhead followed by three other high bursts. Then regular fire began, shells over the train, to the left and in the road. One shell struck 16 feet from the gun. Fragments hit the side plates on the left side, cutting the train air line, piercing the plate close to the left elevating wheel and striking the support to the gas engine, breaking one piece of the casting but doing no injury to the engine. This shell interrupted two men in their daily sanitary operation of scrubbing clothes. These two men had been ordered away from the gun when the commanding officer noted the first high burst. They abandoned their clothes bucket only to have the German shell strike it and the fragments flew in all directions, causing minor injury to the gun mount.

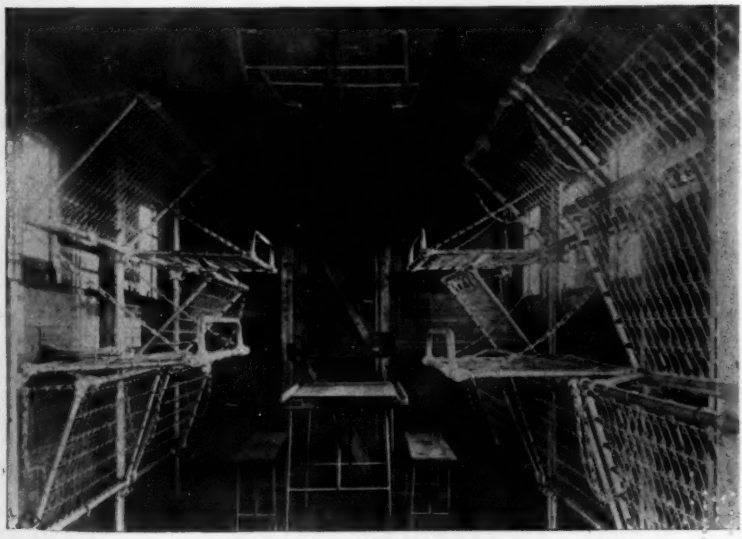
The German retreat from Laon left the former targets of the naval railway batteries in the hands of the Allies. Rear Admiral Plunkett on October 14 visited this sector, going over the ground carefully. It was not difficult to recognize the shell craters formed by the explosion of the 14-inch naval projectiles. They were easily identified by their uniform size and great extent, and, some contained a few fragments of the shells themselves from which identification was made positive. The fragmentation of the shells was most excellent. No "duds" were found. All




AMMUNITION CAR.



PLACING SCREEN OVER GUN-CAR "CAMOUFLAGE."



INTERIOR OF BERTHING CAR.

fuses functioned and the nose of one shell was found five kilometers from the target. General Mangin and the French artillery command were delighted with the work of the guns, for when working with the map only and without aeroplane observation, the shots in nearly all cases were effective hits, and where aeroplane spotting had been possible and the corrections applied on subsequent shots, they had been perfectly placed.

The effect on the railroads leading out of Laon was all that could be desired. One hit from the 14-inch naval guns was sufficient to wreck a railroad line of three tracks for a distance of at least 100 feet, tearing the rails up, shattering the ties and blowing an enormous crater in the road bed. Although the Germans would repair at night the damage done by the guns, and thus maintain some communication, the interruption must have caused them serious concern, both when holding their ground before Laon and also during their retreat.

In the way of concrete evidence regarding the punishment inflicted upon the Germans, Admiral Plunkett learned that one projectile had struck a German moving picture theater during a performance, killing 40 outright and severely mangling at least 60 others. Two other shells struck this same moving picture theater, and it was completely demolished, together with several surrounding buildings. One freight train on a siding had been struck and one car was completely lifted from the track and thrown a distance of about 30 feet.

On October 11, 12 and 13 Battery No. 2, which had taken position at Flavy-le-Martel, southeast of St. Quentin, fired 35 rounds without observation against Mortiers, an important railroad center north of Laon. Nos. 3, 4 and 5 remained at the reserve artillery base of the American Expeditionary Forces at Haussimont until October 12, when they were ordered to take a position at Thierville on the outskirts of Verdun. Three gun pits were put in at this position and two pits put in at Charny, about three miles further north. Attempts were made on several days to get observation, but without success. On October 23 one round was fired from each battery at the railroads passing through Longuyon, 38,580 yards map range. But due to heavy mists the aviator was unable to observe. On October 29, due to the activity of the enemy's forces coming into Mangiennes (a concentration

of troops at this point) Batteries Nos. 3, 4 and 5 kept up an intermittent bombardment of the roads leading into this town. Ten rounds were fired from each gun at a range of 26,000 yards.

Batteries Nos. 1 and 2 after having performed so satisfactorily in the vicinity of Soissons with the French 10th Army, were ordered to join the 1st American Army of the A. E. F. The two guns arrived at Nixeville, just south of Verdun on October 28. Battery No. 2 immediately occupied one of the gun positions prepared at Charny, and Battery No. 4 was moved from Thierville to the other position there.

It was absolutely impossible to get satisfactory aeroplane observation. Six rounds from Batteries Nos. 3 and 4 were fired at open fields near the targets, in order that aeroplane photographs could be obtained and the range corrected accordingly. On the 30th and 31st six rounds per gun were fired on each day. The two guns at Thierville firing at an aviation field south of Longuyon, and the two guns at Charny at points near Montmedy. Aviators flew over the targets shortly afterward, but due to their height, 5200 meters, satisfactory photographs were not obtained.

Battery No. 2 bombarded the railroad yards of Montmedy with 43 rounds on November 1 and 2. At this time General Foch was preparing for an enormous offensive east of Metz, and the French requested that two of the naval railway battery mounts be assigned to take part in this important operation.

It was decided that Batteries Nos. 1 and 2 should be assigned to comply with this request of General Foch, while the remaining batteries would remain at Thierville and Charny to keep up the bombardment of Montmedy and Longuyon. Battery No. 2 left Charny on November 3 and arrived at its firing position at Moncelle-Luneville in the forest of Mondon on November 9; meanwhile, Battery No. 1 had arrived at its firing position in the forest of Velaine via Champigneulles on November 6, the objective being Bensdorf. This latter position was about 20 miles east of the one occupied by Battery No. 2. The target assigned to Battery No. 2 was Saarburg. Both targets were important German railroad centers.

In this territory much more work in the preparation of the gun positions was necessary than at any other firing point that

had been assigned. The soil was wet clay, and it was difficult to install the pit foundation. A track for bringing up the gun was not available, and it was necessary to fell trees and prepare the necessary road bed. The entire forest of Champenoux was alive with the preparation of gun emplacements and with the movement of troops preparatory to the great push. The greatest caution had to be taken in all movements of trains, for the Germans were continually opening up with their artillery at the least evidence of a locomotive or other vehicle of transportation. Batteries Nos. 1 and 2 were assigned to positions much nearer to the front lines than customary, and it was apparent from the tremendous array of field pieces, howitzers, mortars, and other weapons that the Allied command contemplated a very heavy movement due east in this sector, supported by the 3d, 7th, 8th and 10th French armies. The artillery in place, and the accumulation of mobile artillery in the rear exceeded all previous offensive preparations of the war, and with the veteran armies which were to make this thrust, it is quite apparent that had the armistice not gone into effect when it did, Metz would have been taken from both the north and the south, and the possible ending of the war would have occurred similar to the French surrender at Metz in 1870, only on a larger scale.

Battery No. 3 was shifted from Thierville to Battery No. 2's position at Charny, and on November 1 fired one round at the railroad yards of Longuyon, map range 38,380 yards. Battery No. 4 fired 23 rounds into Montmedy, map range, 37,370 yards, and Battery No. 5 fired 44 rounds at the transportation centers of Longuyon. Again, on November 2, Batteries Nos. 3 and 5 each fired 25 rounds at Longuyon, and Battery No. 4, 20 rounds at the railroads of Montmedy. On account of the enemy's activities at Louppy and Remoiville Battery No. 4 on November 3 fired 25 rounds on a large ammunition dump, and on the cross roads and bridges there. After firing six rounds at the lower railroad garage, at Montmedy, on November 4, Battery No. 4 again took up position at Thierville on account of the weakened condition of the pit, making it inadvisable to continue firing from this point. Battery No. 3 opened fire on Louppy and Remoiville on the morning of November 4, firing 44 rounds at the two targets; 12 rounds were also fired at Montmedy.

All of the firings above mentioned were intermittent, covering a period each day of 6 to 12 hours. In case of a contemplated advance the firing generally began two to four hours before the infantry attack.

To continue the enumeration of all the firings conducted by the United States naval railway batteries would be too tedious, and in order that the offensive measures that may be accomplished by even so small a number as five efficient, high-powered, long-range guns may be appreciated, a summary of their operations follows:

REPORT OF FIRING—BATTERIES NOS. 1 AND 2

| Date | Battery | Gun position | Objective | No. of shots |
|---|---|---|---|---|
| Sept. 6 | 2 | Rethondes. | Tergnier. | 1 |
| 14 | 2 | Fontenoy-Ambleny. | Beny-Loisy. | 10 |
| 15 | 2 | Fontenoy-Ambleny. | Beny-Loisy. | 12 |
| 28 | 1 | Soissons. | Laon. | 47 |
| 30 | 1 | Soissons. | Laon. | 35 |
| Oct. 2 | 1 | Soissons. | Laon. | 30 |
| 3 | 1 | Soissons. | Laon. | 19 |
| 9 | 1 | Soissons. | Laon. | 25 |
| 10 | 1 | Soissons. | Laon. | 43 |
| 11 | 1 | Soissons. | Laon. | 43 |
| 12 | 1 | Soissons. | Laon. | 43 |
| 10 | 2 | Flavy-le-Martel. | Mortiers. | 35 |
| 11 | 2 | Flavy-le-Martel. | Mortiers. | 35 |
| 12 | 2 | Flavy-le-Martel. | Mortiers. | 35 |
| 30 | 2 | Charny. | Montmedy. | 6 |
| 31 | 2 | Charny. | Montmedy. | 6 |
| Nov. 1 | 2 | Charny. | Montmedy. | 43 |

REPORT OF FIRINGS—BATTERIES NOS. 3, 4 AND 5

| Date | Gun | Range | Objective | Gun position | No. of shots |
|---|---|---|---|---|---|
| Oct. 23 | 3 | 38,380 | Longuyon. | Thierville. | 1 |
| | 4 | 38,470 | Longuyon. | W. of Verdun. | 1 |
| | 5 | 38,580 | Longuyon. | W. of Verdun. | 1 |
| 29 | 3 | 25,900 | Mangiennes. | Thierville. | 10 |
| | 4 | 25,990 | Mangiennes. | Thierville. | 10 |
| | 5 | 26,080 | Mangiennes. | Thierville. | 10 |
| 30 | 3 | 36,830 | Av. Fld., Longuyon. | Thierville. | 6 |
| | 4 | 39,340 | Tunnel, Montmedy. | Charny. | 6 |
| | 5 | 36,800 | S. Longuyon. | Thierville. | 6 |
| 31 | 3 | 36,830 | Av. Fld., Longuyon. | Thierville. | 6 |
| | 4 | 39,340 | Tunnel, Montmedy. | Charny. | 6 |
| | 5 | 36,800 | S. Longuyon. | Thierville. | 6 |
| Nov. 1 | 3 | 38,380 | Longuyon. | Thierville. | 1 |

REPORT OF FIRINGS—BATTERIES NOS. 3, 4 AND 5—*Continued*

| Date | Gun | Range | Objective | Gun position | No. of shots |
|---|---|---|---|---|---|
| Nov. 1 | 4 | 37,670 | Garage, Montmedy. | Charny. | 23 |
| | 5 | 38,580 | Longuyon. | Thierville. | 44 |
| 2 | 3 | 38,380 | Longuyon. | Thierville. | 25 |
| | 4 | 37,670 | Garage, Montmedy. | Charny. | 20 |
| | 5 | 38,580 | Longuyon. | Thierville. | 25 |
| 4 | 3 | 28,840 | Louppy. | Charny. | 27 |
| | 3 | 27,910 | Garage, Remoiville. | Charny. | 17 |
| | 3 | 36,850 | Low. Garage, Mont. | Charny. | 12 |
| 3 | 4 | | Louppy. | Charny. | 12 |
| | 4 | | Garage, Remoiville. | Charny. | 13 |
| 4 | 4 | 37,670 | Low. Garage, Montmedy. | Charny. | 6 |
| 5 | 3 | 36,850 | Low. Garage, Montmedy. | Charny. | 11 |
| | 3 | 38,200 | Upp. Garage, Montmedy. | Charny. | 39 |
| 7 | 3 | 38,520 | Bridge, Montmedy. | Charny. | 50 |
| 8 | 3 | 36,850 | Low. Garage, Montmedy. | Charny. | 6 |
| 9 | 3 | 36,850 | Low. Garage, Montmedy. | Charny. | 25 |
| | 4 | 25,990 | Mangiennes. | Thierville. | 10 |
| | 4 | 38,470 | Longuyon. | Thierville. | 10 |
| | 5 | 26,080 | Mangiennes. | Thierville. | 10 |
| | 5 | 38,580 | Longuyon. | Thierville. | 5 |
| 11 | 4 | 37,670 | Longuyon. | Thierville. | 5 |
| | 5 | 38,580 | Longuyon. | Thierville. | 5 |

The naval railway batteries fired a total of 782 rounds against the enemy. The guns were fired on 25 different days. There was no such thing as lightly and heavily engaged, and the guns did not engage the enemy. They were used for strategical purposes entirely, and fired at ranges between 30,000 and 40,000 yards. Other artillery, of which there was a great quantity, could accomplish with less expenditure of ammunition and expense all the results that were desired at the shorter ranges. The number of rounds fired at any one time or on one day was governed by the results which they desired to obtain.

The ammunition supply for guns to be used in the field of active operations should be measured entirely by the life of the gun. It was not believed that the accuracy of the 14-inch guns would be more than 300 rounds and the navy's provision for 300 rounds for each gun proved entirely adequate.

In plans for use of long-range weapons under the conditions as they existed on the Western Front, the experience of the United States naval railway batteries demonstrated that it is advisable

to provide spare mounts rather than to provide spare guns. All advices received by the Bureau of Ordnance while they were drawing up plans for the naval railway batteries was to the effect that as many as four guns should be available for each mount, the reason being given that the life of the guns was short and after operating only a few weeks it would be necessary to withdraw the mount and replace the worn-out gun with a new one. The actual operation of the batteries in the great war demonstrated that this policy is not an effective one, for repeatedly it happened that the mounts themselves narrowly escaped destruction by shell-fire and by bombs. The effect of these bombs, had the German control been more efficient, would have been the destruction of the mount, but it is believed that the gun itself would have remained practically intact. So the navy, while the batteries were operating in France, decided that it is advantageous in the operation of heavy guns to provide each gun with a mount and not to hold guns in reserve as spares.

Heavy guns of a long-range type cannot be replaced without excessive delay. The replacement cannot be made at the front, and in all cases it is necessary to remove the battery to some distance behind the lines, where a shop with ample crane facilities is available, and during this interval a gap is likely in the lines. The only solution, and the one which is believed to be the most effective and economical for the operation of railway mounts, is to build the entire unit complete without provision for spare guns, to operate on the front as many as possible at one time, and to hold in reserve another complete unit to replace whichever one may lose its accuracy or to withdraw it entirely when it has ceased to be effective.

No observation was obtained at any time while operating in the Verdun Sector, and the only way of obtaining any idea of the results of the firings was through the Intelligence Service. On November 5 the southern part of Montmedy was reported on fire, on November 11 a German prisoner reported that the firing on Montmedy had caused a great deal of damage, one shell landing in the yards and killing all the Germans in two coaches.

The railway batteries at Charny and Thierville did not operate with impunity. They were repeatedly shelled and bombed as was the case at Soissons. On October 30 Battery No. 2 reported

firing six rounds into Montmedy with a range of 37,382 yards, the first shot at 12.04 p. m., and the last shot at 12.29 p. m. The enemy at the time was shelling cross roads between the gun and the berthing cars. Three American engineers working on the track nearby were killed. The headquarters and one berthing car were derailed and replaced without damage. Battery No. 4, on the same day, reported five other soldiers killed and others injured by enemy shells which fell near the crossing of the roads (railway and wagon) at Charny. One shell which killed two and injured several others fell within 50 feet of the blue-jacket in the naval railway battery telephone control station. Gas masks were always carried and the men of the railway battery had to be continually prepared for casualties. When off duty the men remained in dugouts. On October 28 the following men of Battery No. 4 were wounded by enemy shell-fire:

GUTHRIE, K. W., S. F. 2C, U. S. N., wounded on left leg.
SHARPE, A. P., S. F. 1C, U. S. N. R. F., wounded on left leg.
BURDETT, A. J., S. F. 2C, U. S. N., wounded on face.

Two other men received slight wounds; Sharpe died on October 29 while in the hospital at Glorieux, near Verdun.

The importance of the targets under bombardment by the United States naval railway batteries is indicated by the following passages quoted from the secret field orders issued by Brigadier-General William Chamberlaine, U. S. A., Commanding Headquarters 30th Artillery Brigade (C. A. C.)

"October 18, 1918.

"The towns of Montmedy, Longuyon, Spincourt, and Conflans-en-Jarny are among the most important railroad centers of the enemy's transportation system for the supply of the Western Front."

"October 18, 1918.

"A group of long-range guns more powerful than heretofore assembled for a single operation is now being emplaced to attack the above centers.

"These centers will be attacked on the first day offering favorable observation. The object of this attack will be the destruction of the railroad yards and the rolling stock therein, the interruption of railroad traffic and the general disorganization of the enemy's transport system."

"October 18, 1918.

DETAILED INFORMATION CONCERNING TARGETS—LONGUYON

"Longuyon is an important railroad center, located at the junction of the lateral line from Alsace, through Metz and Thionville to the west and

the main line north through Luxemberg. Hirson-Sedan-Metz line is referred to in a recently captured German document as 'the most important artery of the Army of the West.' The cutting of this line would cripple the German steel production.

"Longuyon is a detraining point. The main railway yard contains 15 long sidings and is normally occupied by about 350 cars. Many of the houses in the town are destroyed, but there are numerous large storehouses in good condition."

MONTMEDY

"Montmedy is on the main railway line from Metz and Luxemberg to Sedan and Mezieres. The civil population, about 3000, is still in the town. The town has a citadel, large barracks, and is the headquarters of the 7th Germany Army. North of the town the railroad enters a tunnel about 800 meters in length. The railroad yard is large and frequently contains 400 cars. 1500 meters north of the town there is an aviation field which recently contained 7 hangars."

CIRCULATION

"Circulation on the line Conflans-Domary-Baron-Court-Spincourt averages one train per hour in each direction. This figure includes both civil and military trains. The greatest circulation is between 10 and 8 hours. Longuyon and Montmedy show considerable night activity."

After the signing of the armistice on November 11, Montmedy, Longuyon, Mangiennes, Louppy and Remoiville were visited, and some of the results of the firing were obtained from observation and from questioning the civilian population that remained. The guns apparently were firing a few hundred yards beyond the ranges calculated from the range table, but the damage to both material and morale was considerable. The targets were struck frequently, and the traffic was stopped completely, not only during the actual firing but from 6 to 10 hours each day after the firing had ceased. As the railroad running through Longuyon and Montmedy was the only line by which troops could be brought to Sedan other than a railroad running far to the north through Belgium, the cutting of this line was a strategical victory of great importance. General Pershing, in his report, states in his description of the last phase of the Meuse-Argonne offensive, "Our large-caliber guns had advanced and were skillfully brought into position to fire upon the important lines at Montmedy, Longuyon and Conflans—the strategical goal which was our highest hope was gained. We had cut the enemy's main line of communica-

tions and nothing but surrender or an armistice could save his army from complete disaster."

All of the naval railway batteries were ordered back to the R. A. R. base, at Haussimont a few days after the armistice took effect, arriving there on November 22. On November 28 the staff train left Haussimont for St. Nazaire, via Paris, and the other trains followed, one per day, on the succeeding days. By December 11 all batteries had arrived at St. Nazaire. On the same day a draft of 150 men and six officers left for the United States through Brest. On December 13 and 17 the remainder of the personnel left St. Nazaire for the United States, via Brest, with the exception of one officer and 20 men, who were detailed to remain with the guns with orders to disassemble and ship them home at the earliest opportunity. Rear Admiral C. P. Plunkett, U. S. Navy; Lieut. Commander J. W. Bunkley, U. S. Navy, his executive officer while commanding the United States naval railway batteries, and a majority of the personnel of the railway batteries, arrived in New York on Christmas Eve, 1918, and the entire expedition would have been home before New Year's except that two or three officers and a number of men were so unfortunate as to be delayed when the *Northern Pacific*, on which they took passage, ran aground on Fire Island.

"Extracts from Confidential Bulletin No. 231, November 7, 1918, from Vice Admiral Sims, sent to Bureau of Ordnance by direction of the Chief of Naval Operations:

"The 14-inch 50-caliber United States naval railway guns have done very excellent and valuable work, particularly in the recent pushes. Three of these guns have been in the sector opposite Mezieres, and have had the railways to and from that place under effective gun fire for some time.

"The accuracy of these guns has proved greater than was expected. With a gun that had fired 150 rounds, 24 observed rounds were fired at a range of 35,800 yards. The mean dispersion obtained was plus or minus 151 yards in range, and plus or minus 51 yards in deflection. The ballistic correction in this case was about 2800 yards. The shots were fired about 5 minutes apart.

"Considering the relation of the total pattern size to mean dispersion in a salvo, it is estimated that these results would work out, in the case of a 12-gun salvo, to a pattern of about 650 yards in range and about 220 yards in deflection at 35,800, the guns being all considered as having fired about 150 times since proof. A careful analysis of the results obtained under existing conditions appears to indicate that a gun may shoot accurately while both muzzle erosion and considerable coppering exists."

This article may have seemed to the reader to contain much detail, but in its preparation it was desired to inform the members of the Naval Institute, and the many friends of the navy, of what was done. It is unfortunate that during actual hostilities the preparation, organization, and operations of projects similar to the above cannot be disclosed; for, during the trying days of the spring and summer of 1918 it would have been most pleasing to the Navy Department if they could have given the facts concerning the accomplishments of the naval railway batteries to the public from day to day, in the form of a continuous story. It would have proved most interesting and inspiring for the American people to have known the rapidity with which the material for the batteries was completed at home; the safety with which it was transported abroad, the speed with which it was assembled at St. Nazaire, and to have heard from day to day of the operations of the various guns while on the Western Front.

Perhaps the navy will gain its greatest satisfaction from the accomplishment of Admiral Plunkett's expedition in knowing that all of the ordnance material operated without a casualty worthy of mention. To the Bureau of Ordnance it has given the greatest confidence in the ordnance equipment as installed on our naval vessels. On no occasion did the personnel of the batteries suffer from failure of any part of the gun or mount. The total rounds per gun fired were:

| | |
|---|---|
| Battery No. 1 | 199 |
| Battery No. 2 | 113 |
| Battery No. 3 | 236 |
| Battery No. 4 | 122 |
| Battery No. 5 | 112 |
| Total | 782 |

When this record of firing from five different guns is known to have been made under service conditions, in the field, without a single casualty to material, it must give the personnel of our entire navy absolute confidence in their guns, mounts, ammunition and ordnance material as installed on the *Mississippi*, *New Mexico* and *Idaho*. There is every reason to believe that the guns on these ships, and on the other ships of our fleet, are sufficiently strong to go into battle and fire continuously until the record of Naval Railway Battery No. 3, of 236 rounds, has been equalled or bettered.

The last shot from the United States naval railway batteries was fired by Battery No. 4, from its position at Charny. This shot was fired at 10.59 a. m., into Longuyon by James A. Kaffka, S. F., 1st class, U. S. Navy, who energized the firing key and caused the primer to function. This primer is now in the possession of Rear Admiral Earle, chief of Bureau of Ordnance. A copy of Marshal Foch's letter terminating hostilities follows because of its historical interest.

VIII^e Armée

État-Major

3^me Bureau

N° 8272 NOTE DE SERVICE

Le Maréchal Foch télégraphie ce qui suit:

"Maréchal Foch à Commandants en Chef:

"1°/. Les hostilités seront arrêtées sur tout le front à partir du 11 (Onze) Novembre, 11 (Onze) heures (heure française).

"2°/. Les Troupes Alliées ne dépasseront pas jusqu'à nouvel ordre la ligne atteinte à cette date et à cette heure."

Copie conforme notifiée pour exécution.

P. O. Le Chef d'État-Major,
Douchy.

---

VIII^e Armée
Artillerie
R. G. A.
N° 6122

Notifié à: B^a Naval Américain N° 1.

Le 11 Novembre, 1918,
Le Général Cdt. l'Artillerie de l'Armée,
P. O. le Chef d'Escadron R. G. A.
Mercueillin.

## LIST OF OFFICERS ATTACHED TO U. S. NAVAL RAILWAY BATTERIES

Plunkett, Charles P., Rear Admiral, U. S. N., Commanding.

Schuyler, Garret L., Commander, U. S. N., Ordnance, gunnery and orientation.

Bunkley, Joel W., Lieut. Commander, U. S. N., Executive, gunnery and orientation.

Buell, Dexter C., Lieut. Commander, U. S. N. R. F., Construction Officer (detached September 30, 1918).

Hayden, Joseph R., Lieutentant, U. S. N. R. F., Train Commander, gunnery and orientation.

Smith, William G., Lieutentant, U. S. N., Train Commander, gunnery and orientation.

Martin, James A., Lieutenant, U. S. N., Train Commander, gunnery and orientation.

Rodgers, James L., Lieutenant, U. S. N. R. F., Train Commander, gunnery and orientation.

Duckett, Edmund D., Lieutenant (JG), U. S. N., Train Commander, gunnery and orientation.

Davis, Homer B., Lieutenant (JG), U. S. N. R. F., Assistant to Train Commander.

Orr, M. B., Lieutenant (JG), U. S. N. R. F., Assistant to Train Commander.

Grylls, Humphrey M. K., Ensign, U. S. N. R. F., Assistant to Train Commander.

Allen, Roger, Ensign, U. S. N. R. F., Assistant to Train Commander.

Raymond, Philip T., Ensign, U. S. N. R. F., Assistant to Train Commander.

Davis, Winfield C., Ensign, U. S. N. R. F., Gas Officer and Assistant to Train Commander.

Cheffy, George, Ensign, U. S. N. R. F., Assistant to Train Commander.

Davis, Parlett L., Ensign, U. S. N. R. F., Assistant to Train Commander.

Linhard, Leon J., Ensign, U. S. N. R. F., Assistant to Train Commander.

LeBlanc, Thomas J., Ensign, U. S. N. R. F., Transportation Officer.

Primeau, Albert K., Ensign, U. S. N. R. F., Assistant to Train Commander.

Baldwin, Frank, Lieut. Commander (Pay Corps), U. S. N., Paymaster and Supply Officer.

Stephenson, C. S., Lieut. Commander (Med. Corps), U. S. N., Senior Medical Officer and Gas Officer.

Morris, Laird M., Lieutenant (Med. Corps), U. S. N., Junior Medical Officer and Gas Officer.

Bugbee, Edwin P., Lieutenant (Med. Corps), U. S. N. R. F., Junior Medical Officer and Gas Officer.

Field, Thomas S., Lieutenant (Med. Corps), U. S. N., Junior Medical Officer and Gas Officer.

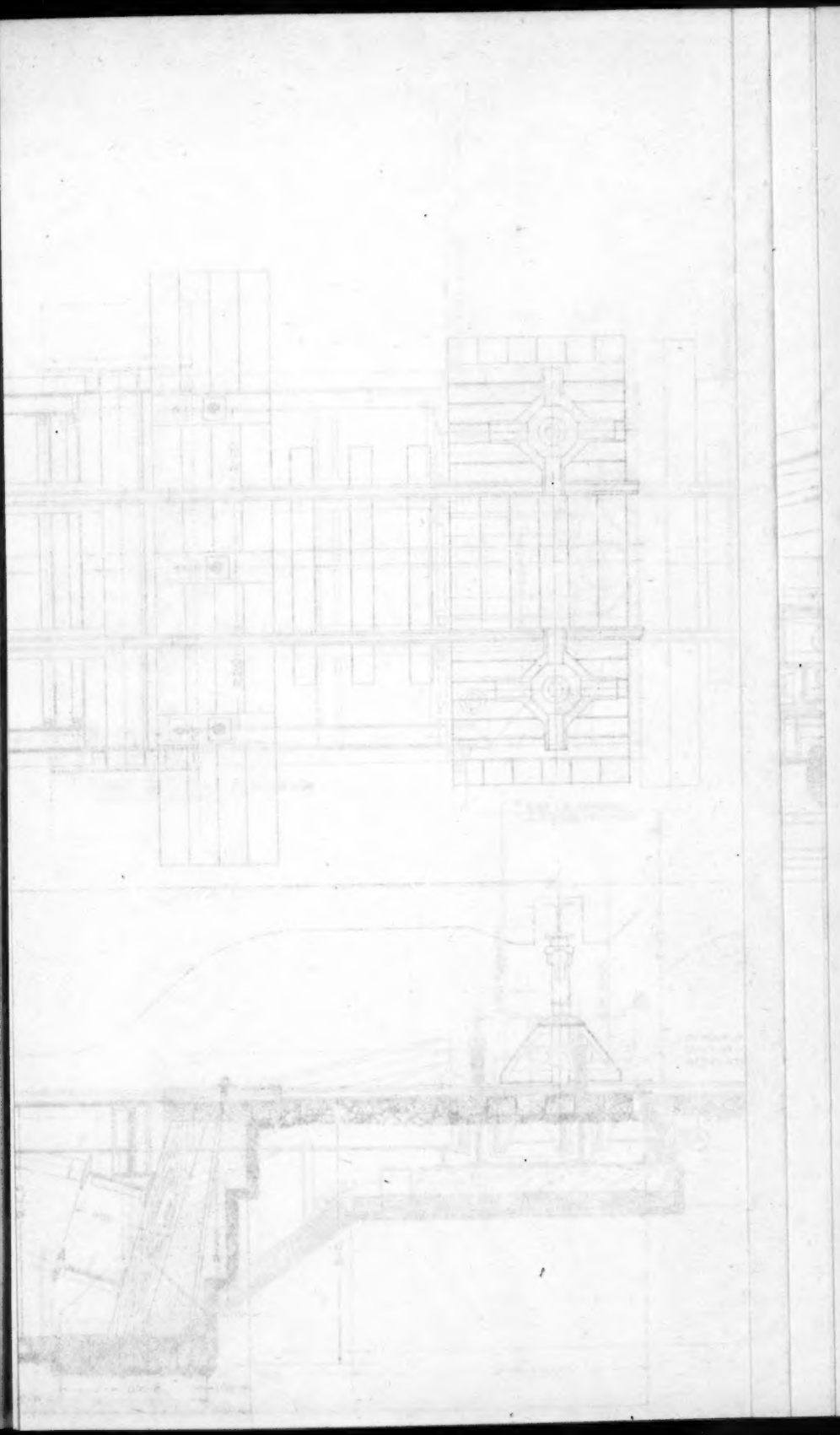
Andrews, E. D., Lieutenant (Med. Corps), U. S. N., Junior Medical Officer and Gas Officer.

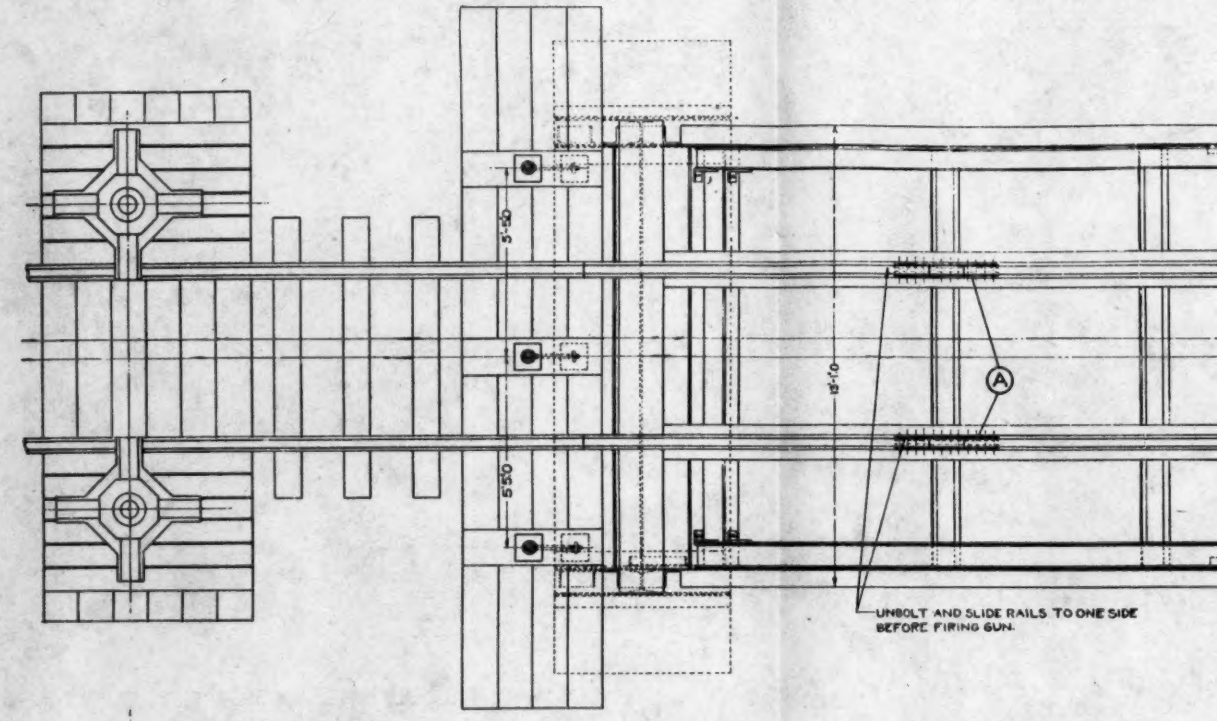
Carr, George P., Lieutenant (Med. Corps), U. S. N., Junior Medical Officer and Gas Officer.

Eubank, Gerald L., Ensign (Pay Corps), U. S. N. R. F., Assistant to Supply Officer.

Gaffney, Francis L., Ensign (Pay Corps), U. S. N. R. F., Assistant to Supply Officer.

Anderson, Oscar E., Pay Clerk, U. S. N. R. F., Assistant to Supply Officer.

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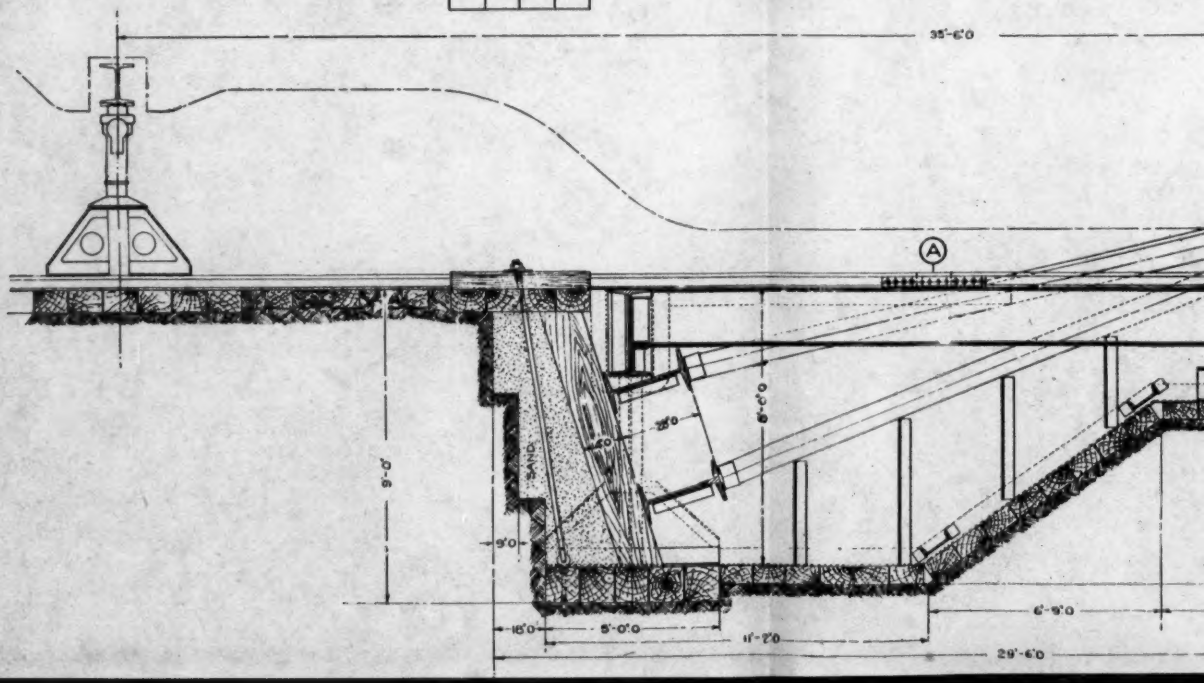
UNBOLT AND SLIDE RAILS TO ONE SIDE
BEFORE FIRING GUN.


35'-6'0
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9'-0"
SAND
9'0
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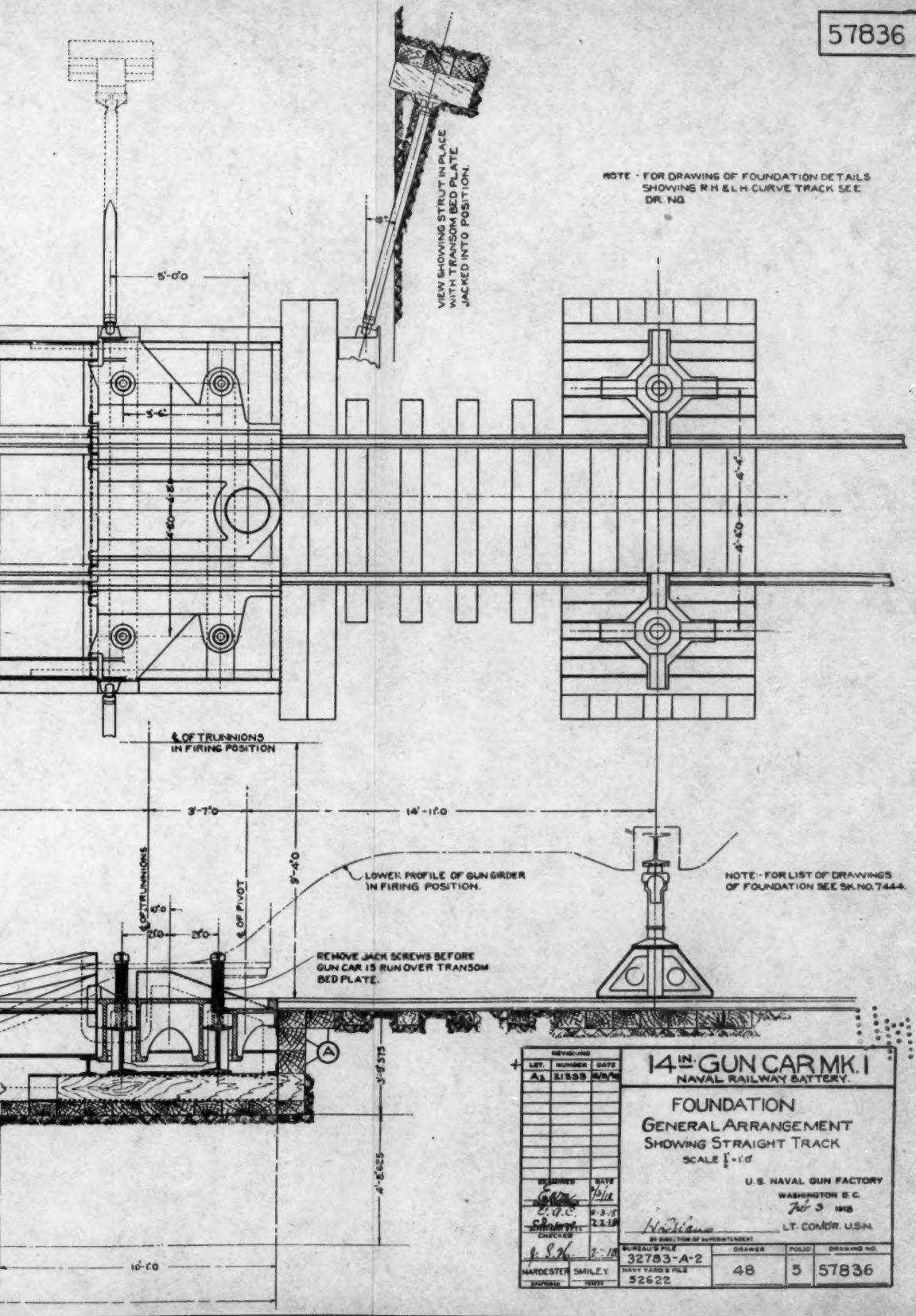
4'0
6'-0"
6'-9'0
1'6"
5'-0'0
11'-2'0
29'-6'0

57836




| REVISIONS | | |
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| A1 | 21333 | 6/5/18 |

# 14 IN. GUN CAR MK. I
## NAVAL RAILWAY BATTERY.

## FOUNDATION
## GENERAL ARRANGEMENT
## SHOWING STRAIGHT TRACK
SCALE ℄ = 1'-0"

U.S. NAVAL GUN FACTORY
WASHINGTON D.C.
Feb 3 1918

LT. COMDR. U.S.N.
BY DIRECTION OF SUPERINTENDENT

| DRAWN | DATE |
|---|---|
| ~~C.W.~~ | ~~2-1-18~~ |
| C.W.C. | 2-3-18 |
| CHECKED | |
| ~~S.W.~~ | ~~2-7-18~~ |
| HARDESTER | SMILEY |
| DRAFTSMAN | TRACED |

| BUREAU'S FILE | DRAWER | FOLIO | DRAWING NO. |
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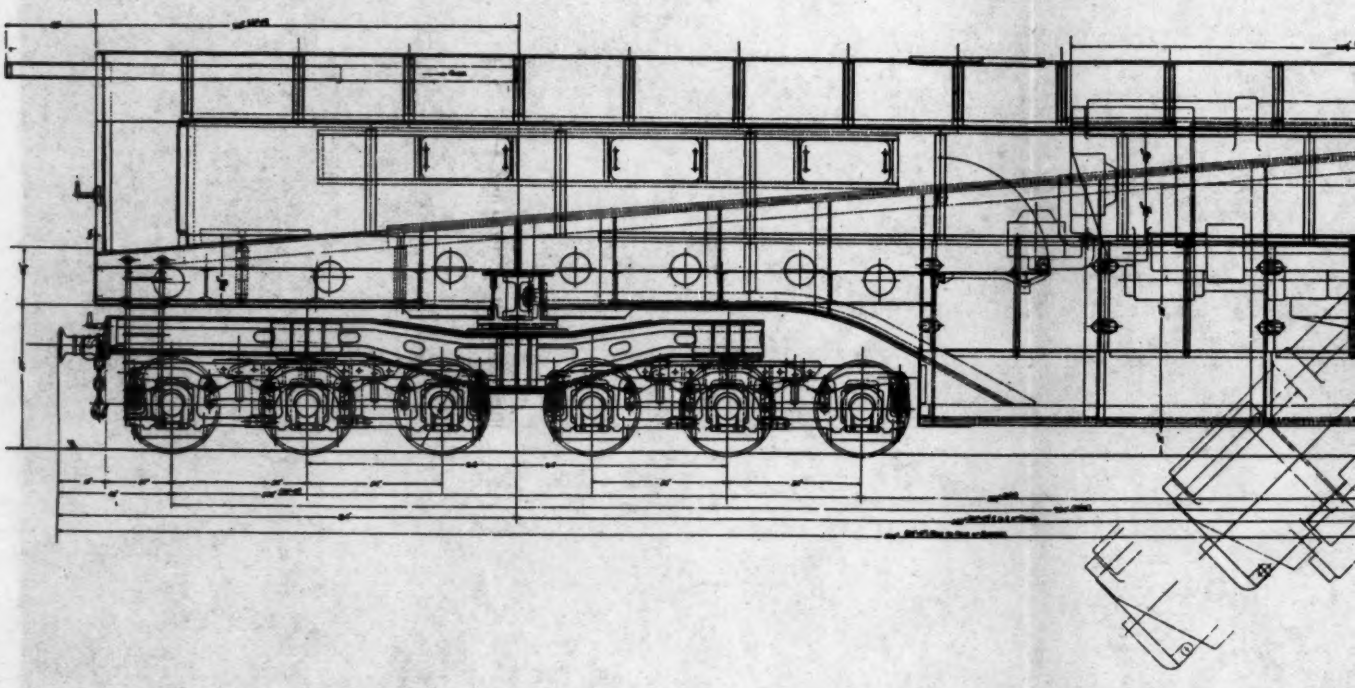

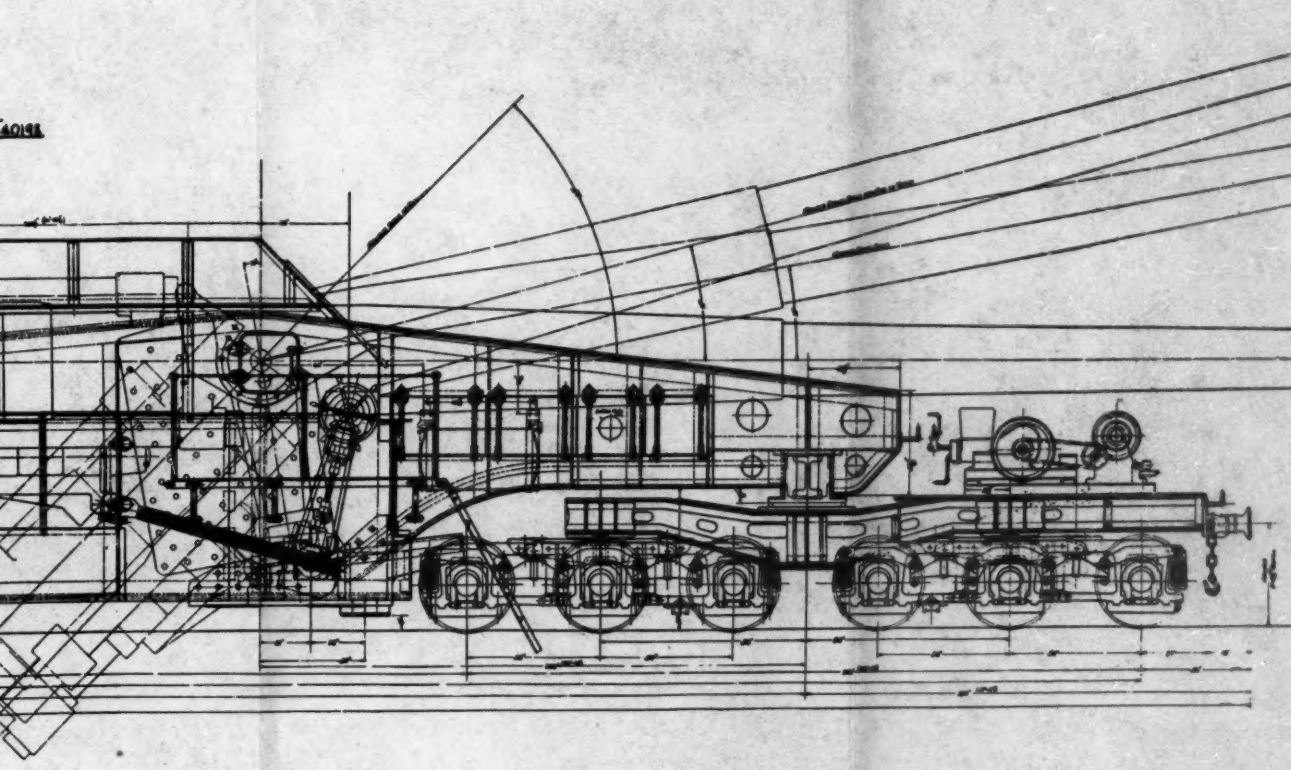

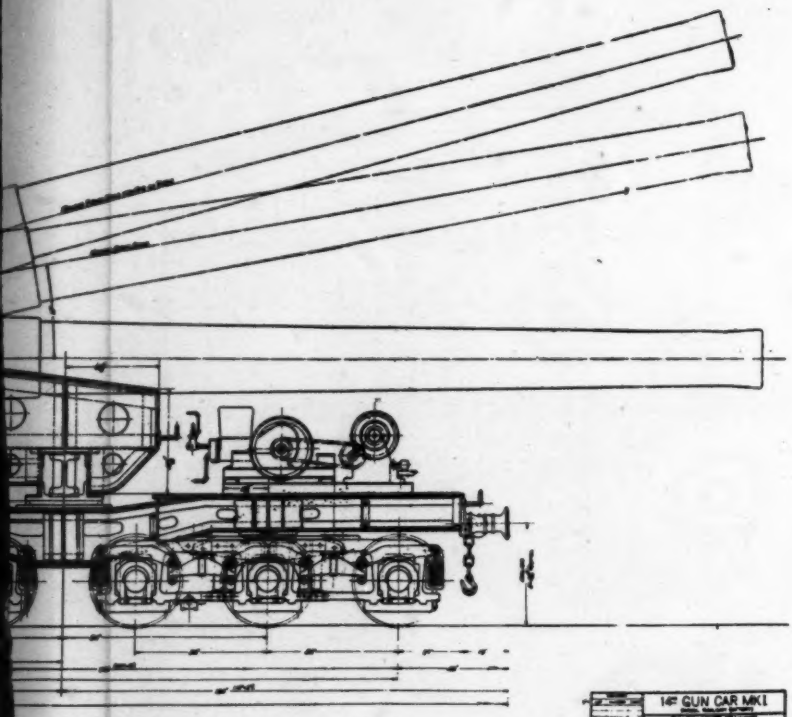

14" GUN CAR MK I.

GENERAL ARRANGEMENT

OUTSIDE ELEVATION

48 15 5821 11

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

Prize Essay, 1917[1]

# COMMERCE DESTROYING IN WAR

By CAPTAIN L. A. COTTEN, U. S. Navy

*Motto:* Easy methods; inconsiderable results.

The science of war as we know it to-day, like all other sciences, is the result of progressive development. As war implements changed by successive stages from the clubs and stones of savagery to the high-power guns of to-day the method of using these implements necessarily changed also, but the object of war has constantly remained the same, namely the reduction of one's opponent to such a state of impotence, actual or prospective, that he considers it the part of wisdom to submit to the will of his enemy.

Since war ceased to be a general *mêlée in* which one savage tribe fell upon another and fought by brute force until one was exterminated or enslaved, man has been more and more seeking to employ his brains as an aid in fighting. Many have reaped the advantage of more effective weapons or a more effective use of their weapons, but many more have striven in vain for a short cut to success in war—some patent nostrum by which victory could be won without taking and giving the hard blows that make war so disagreeable.

In the early ages of human development, sea-borne commerce was practically non-existent, but, so soon as civilization reached the era of colonization, it quickly became an important part of the economic life of the countries that faced the sea, and consequently of great importance in war.

A merchant vessel on the high-seas is particularly helpless to resist force, and furthermore constitutes, with her cargo, a con-

[1] Essay received by U. S. Naval Institute, December 30, 1916. Published without change.

centrated form of wealth. The sea offers no facilities for concealment, and the lanes of maritime commerce converge in certain localities on account of physical features, as islands, straits or smaller seas, making the location of merchant ships fairly simple. Seeing this, some seeker for success-in-war-without-fighting evolved the idea of commerce destroying as the long-sought short cut to easy, economical and successful war.

He argued in this way. We will build ships of less cost than heavy men-of-war, and send them out to prey upon this helpless maritime wealth of our enemy. These ships will infest the regions in which his merchant ships converge, and by capturing or destroying them we will bring him to the verge of bankruptcy, at the same time enriching ourselves at his expense. This reasoning seemed plausible, and this means of winning war on the sea appeared to be both simple and economical, and straightway there arose a school of adherents, both naval and civilian, though it must be said that it always appealed with more force to those who *direct* the conduct of war than to those who actually have to execute it. In any case, from that day to this, most maritime wars have seen commerce destroying used with varying degrees of insistence.

That great student of naval history, Admiral Mahan, said: "There are certain teachings in the school of history which remain constant," and it would seem to be not without interest to see what lessons the school of history contains on commerce destroying in war, with special attention to its final result and its association with victory or defeat. Such lessons should be of particular interest at this time, when commerce destroying is being undertaken on an extensive scale and a new instrument, the submarine, is being employed in its service.

A survey of the history of commerce destroying will necessarily have to be very brief to be compassed in reasonable space, but even so, we may be able to deduce something therefrom of value to our country and of interest to ourselves. Such a survey may be divided logically into two parts, *i. e.*, commerce destroying in former wars and commerce destroying in the present war. By handling the subject in this way we may more accurately gauge the present by the known results of the past, and after all, such a survey can have real value only in so far as it leads to a clearer understanding in the momentous present.

It is not necessary for our purpose that we go back in history for a further period than to enable us to cite sufficient examples upon which to base our deductions with reasonable safety. By the middle of the sixteenth century maritime commerce had risen to a position of great economic importance in the national lives of several European countries, particularly Spain. Her galleons usually voyaged several together, the better to defend themselves from the pirates and freebooters of that day, and on their homeward voyages were laden with cargoes of great value.

When England under Elizabeth and Spain under Philip went to war, partly for "the glory of God," and partly for the privilege of trade with America, the Spanish Navy was at the height of its glory, while the English Navy had yet to win its distinction, and to become imbued with those correct principles of naval warfare that for so long have maintained England in her world position. At this time England was a comparatively poor country, and first-line men-of-war were expensive, so for some years she made direct war on the commerce of Spain her chief objective, at the same time pillaging and destroying her colonial cities as occasion permitted.

At first this mode of warfare seemed to meet with considerable success, but, none-the-less, when Philip began building and fitting out a vast number of fighting ships, England found herself threatened with invasion, *which commerce destroying was powerless to stop*. Though Drake covered himself with glory when he "singed the King of Spain's beard for him" at Cadiz, the preparations for invasion were only delayed, not stopped.

After much delay through vacillation and economy, the English began to prepare a fighting fleet, and finally were able, though vastly outnumbered, to "defy the Duke Medina" and scatter to the winds the Great Armada.

Then it was that the English found that in saving England from invasion *by destroying the Spanish war-fleet*, they had also greatly simplified the problem of trade with America, and had put the commerce of Spain almost at their mercy.

For fifty years or more after this, England put her reliance in maritime war in her fighting fleet; but plausible fallacies die hard, and in the second Anglo-Dutch war the English showed they had only half-learned their lesson. Charles II, as usual, was short of

money and, besides, the war was waged primarily over the question of maritime commerce, so again England made direct war on commerce, though several fleet actions took place. In these actions the English Navy, while winning no decisive victories, still maintained its position very satisfactorily. After the battle off the North Foreland, Charles, for purposes of economy, decided to put most of his fighting ships out of commission, and concentrate upon commerce destroying. The ineffectiveness of such action may be clearly seen, since the Dutch fleet entered the Thames River in 1667 and inflicted enormous damage, and England was quite willing to come to terms of peace containing no advantages for herself, except escape from the then vastly superior Dutch fleet.

England wholly learned her lesson this time, and not since the Peace of Breda, signed after De Ruyter's raid up the Thames, has she used commerce destroying as a primary mode of maritime war. On the contrary her own commerce has been attacked directly a number of times, but nevertheless it has continued to grow until it has become greater than that of any other country.

France has been the most faithful adherent of commerce destroying, having used it intermittently in her naval wars for over a hundred years. Over and over again it was demonstrated that it led to no considerable military advantage, but still she clung to it with a tenacity worthy of a better cause.

In the third and last Anglo-Dutch war, in which France was allied with England, each of the powers used their fighting fleets, rather than commerce destroying, and finally the Dutch sea power was destroyed and with this destruction Dutch commerce was *automatically* toppled from its pedestal of supremacy.

Again, in the War of the League of Augsburg, we see France taking the sea with fighting fleets and England, now allied with the Dutch, was partially defeated at the Battle of Beachy Head, though the next year Admiral Russell took the sea with a greater force than Tourville could gather. However, by skillfully handling his fleet Tourville drew the English fleet well out into the Atlantic, and during its absence the French light cruisers fell upon English commerce and inflicted enormous damage.

During this campaign, it should be noted, there was no actual fighting, and yet the injury to England was considerable. Here we probably have the origin of the French belief in the efficacy of

commerce destroying as a primary mode of warfare on the sea. "Why," they argued, "have expensive fighting fleets when such injury can be done our enemy by cheaper cruisers and privateers." They quite overlooked the fact that their main fleet, by drawing off the English fleet in pursuit, gave to their cruisers the temporary immunity that enabled them to operate successfully.

The following year the French fleet was badly worsted at La Hogue, but direct war on commerce was continued on a scale previously unknown. Gradually, though, as the French Navy declined in fighting ships, their commerce destroyers were chased from the seas, and with sea control in England's hands French maritime commerce disappeared and its place was taken by England's increasing fleet of merchant vessels. As the disparity in fighting ships increased it became progressively more dangerous for the French commerce destroyers to go to sea, and more difficult for them to make captures even when they could keep the sea.

The part of a commerce destroyer is to destroy merchant vessels, not to fight, and consequently French commerce destroyers were usually so busy keeping out of the way of English men-of-war that they had but little opportunity to ply their vocation. Where the lanes of commerce converged, and captures should have been easy, England stationed men-of-war more powerful than commerce destroyers and the French ships had to seek their victims in more sparsely traversed regions, where captures were few. The peace terms were most humiliating to Louis XIV, and his comparatively successful war on commerce was in no way comparable to the *military* success on the sea of his enemy.

When the war of the Spanish Succession began France at first tried squadron warfare in rather a half-hearted way, but the ease and seeming economy of war on commerce again lured her away from the true principles of naval warfare. During the first five years of the war France captured or destroyed on an average about 230 English ships per year, but England captured more French ships during that time, though her fleet was primarily engaged in military operations that were not without great influence in leading up to the treaty of Utrecht, so disastrous to France. The individual exploits of some of the French privateering commanders were illustrious, but none-the-less the end of the war found France

humbled and defeated and English sea power with its protecting wing at its height.

In the war of the Austrian Succession the naval history of the war of the Spanish Succession in effect repeated itself. France started off as though to fight her part in the war on the sea, but soon commerce destroying was again the accepted mode and the treaty of Aix-la-Chapelle in 1748 restored to France none of the concessions made by the treaty of Utrecht.

In the Seven Years' War between France and England we see another deplorable result of seeking an easy mode of warfare, for though the French fought on occasion, they were ever on the defensive—always willing to await the attack of their enemy—rather than seeking in aggressive action to deliver the heavy blows necessary to overcome an enemy, even if heavy blows have to be accepted in doing so. They seem to have thought that by making a *pretence* of fleet warfare they could impart the element needed to make commerce destroying effective as a means of bringing their enemy to terms.

It is quite true that England suffered the loss of many merchant vessels, but French commerce was practically denied the use of the sea by the English fleets, and, after all, the percentage of loss to the English was small. Her ships were now carrying both her own normal commerce and that abandoned by France. The financial loss to England was scarcely more than a small war tax upon maritime commerce, never amounting to more than 3 or 4 per cent per year. In the meantime England was taking the French colonies one by one, far more than compensating herself in a financial way for the small war tax, and at the same time establishing the foundation of the British Empire.

The treaty of Paris in 1763 left in English hands Canada, Nova Scotia, the Ohio valley, the country east of the Mississippi to New Orleans and numerous small West Indian islands, and *a navy powerful enough to keep them.* The practical results of France's war on English commerce were absolutely without effect when it came to signing the treaty of peace. Comment is unnecessary.

In the maritime part of the War of the American Revolution, France swung away from war on commerce and rather consistently followed squadron warfare, but the infection of non-aggressive action was still there as a legacy from the less rigorous

mode of warfare. Still the results of the war were much more satisfactory to France than were those in which war on commerce had been accorded a more prominent part.

It is nothing short of remarkable that the French, after their years of failure to attain any material advantage through war on commerce, should again revert to it, yet they did no less. In the French Revolution the Committee of Public Safety announced "The new system of political warfare that your committee has adopted. . . . All our plans, all our cruises, all our movements in port and at sea, will have for object only to ravage its (England's) commerce, to destroy, to overturn its colonies, to force it finally into a shameful bankruptcy." That this system was termed new, can only be attributed to an utter lack of familiarity with naval history in general and with French naval history in particular.

It cannot be denied that for some years many English merchant ships were captured, and it was doubtless a source of annoyance to English merchants, but the monetary value of these ships was but a very small part of the total expense of war, and during these years, despite captures, English commerce actually increased. The "shameful bankruptcy" failed to materialize. As a matter of fact the French captures per year averaged only from 2.5 to 3.0 per cent of England's merchant fleet, which does not seem a very heavy war tax.

In the Napoleonic Wars, the French, though their military operations were directed by a master mind, still hoped to gain some advantage through war on commerce at sea. They fought several memorable fleet actions, it is true, but they were always the attacked, and it would seem as though the hearts of their seamen were ever longing for some less violent form of warfare, some easy mode of success, some method of "making war without running risks," as Napoleon himself said. For several years after Trafalgar, war on commerce was followed with energy and persistence, but one by one the French cruisers were sunk, captured or wrecked, and their own shipping, lacking the protecting influence of fighting squadrons, practically disappeared from the high seas.

The numerous examples from French history have been cited, because for a hundred years there were practically only two naval powers, and their modes of conducting warfare were diametrically

opposite. England, profiting by the lessons learned from her wars with Spain and Holland, took the sea, whether inferior or superior in numbers, ready and eager to fight, and her objective was ever the fleet of her enemy. France over and over again sought by inconclusive maneuvers and commerce destroying to bring her enemy to terms. The known results of the various wars individually, and the cumulative total of a hundred years, illustrate more clearly than mere words may hope to do, the strength of the one method and the weakness of the other. It may be accepted as a maxim of warfare that what is worth having is worth fighting for, and easy methods lead to inconsiderable results.

Only a few more examples of commerce destroying prior to the present war will be mentioned, and these only because being less remote historically, they are more generally familiar, and because one famous example of war on commerce is of particular interest to Americans.

During our Civil War the South, having but few men-of-war, used them largely in warring upon the sea-borne commerce of the North. Three ships, the *Florida,* the *Shenandoah* and the *Alabama,* were particularly successful, but the importance of their operations has been vastly magnified by the romantic appeal of their careers, and the concurrent decline in American shipping that has lasted to the present time.

The *Alabama* was the most celebrated of these commerce destroyers, and yet she averaged only three captures per month, and the total loss by capture of the commerce of the North during the entire war, according to a congressional investigation made soon thereafter, was only 5 per cent of the whole, or 1¼ per cent per year. This does not impress one as being an exorbitant war tax on any branch of commerce. That these commerce destroyers were able to accomplish even as much as they did was due more to faulty methods of commerce protection on the part of the North, than to any inherent value in this mode of warfare.

While the commerce of the North was very seriously injured by the direct attack upon it, it is generally lost sight of that the commerce of the South was practically prohibited on the high seas by the purely military disposition of the Northern fleet. That this military disposition was a most effective factor in defeating the South, no one familiar with the history of the Civil War can doubt. At the same time it is highly improbable that the total result of

the Southern commerce destroyers prolonged the losing struggle of the Confederacy by so much as one day, nor would the result of the war have been different had there been a hundred *Alabamas* —so long as they were used purely as commerce destroyers.

The permanent decline of American maritime commerce was due much less to commerce destroying than to legislative, economic and fiscal causes subsequent to the war.

In the Spanish-American War neither combatant had a merchant fleet worthy of the name, and so it affords no examples of war on commerce, though our men-of-war, of course, captured such Spanish merchant ships as came their way. The war was in effect concluded by the destruction of the Spanish fighting squadrons at Manila and Santiago.

In the Russo-Japanese War the Russian division based on Vladivostok made several raids on Japanese commerce, in one case getting as far down as the entrance to Tokyo Bay, but the influence of these raids on the final result of the war was absolutely nil. The Japanese refused to draw any part of their main fleet away from their strictly military objective—the Russian fleet of fighting ships in Port Arthur.

Even in this mere outline sketch of commerce destroying in past wars, it may be seen that certain facts repeat themselves with such consistency that we can but conclude that they belong to the constant teachings in the school of history. We see that commerce destroying has ever been used by the nation having the weaker navy—weaker in fighting ships, in morale, or in the willingness to run the legitimate risks of normal war on the sea; that the main incentives to such warfare are economy and the longing for an easy way to success in war; that the surest way of accomplishing the ruin of an adversary's commerce is to destroy the fighting force that protects it, rather than to make direct war on commerce; that commerce attacked directly sometimes actually increases in war, when protected by adequate fighting ships properly used; that, at its best, commerce destroying has been able to inflict no more than a small percentage of loss on an enemy's total maritime commerce; that the monetary loss to an enemy caused by attacking her merchant ships has never amounted to more than a very small fraction of the cost of war; that an enemy country has never been brought to the verge of bankruptcy through attacking its commerce; that war on commerce has never produced

concrete results of moment tending to reduce an adversary to a state of impotence; and finally that commerce destroying has consistently been practiced by the nation that was, sooner or later, defeated in the essentials of the wars in which this form of warfare was employed.

It is hardly within the bounds of reason that the foregoing clearly discernible facts should have been merely coincidental. There must be some reason for the results, and when these results are similar again and again this reason must be fairly constant, if not fundamental. The results in war are after all the essential things, and when a mode of warfare fails to produce results the reasons for its adoption cease to be of particular interest.

So it is beside the question to advocate commerce destroying in war on account of its original economy, for on the whole its operation is very uneconomical, looking at the war as an entity rather than as a number of parts; it is of no moment to state that war on commerce will reduce an enemy to bankruptcy, since it has never done so; it is futile to the extreme to employ such warfare hoping to win victory thereby, since the history of a hundred and fifty years and more show it to have been ever associated with defeat.

It is not intended that the conclusion is to be drawn that the final results of the various wars were absolutely determined by the types of naval warfare employed, but beyond question the successful use of sea power did have a great influence in each case, and direct war on commerce does not seem to be the most advantageous use of sea power. Since the war is conducted by force it must be terminated by the destruction of force, and so far no easy method of accomplishing this has been evolved.

War on commerce has its uses, for it annoys and weakens an enemy, but as a primary, peace-compelling undertaking it does not produce military advantages of importance. The best way for a combatant nation to protect its own commerce and at the same time drive the commerce of its enemy from the sea, is to destroy the fighting ships of that enemy. That much is certainly true if we are to accept the lessons of history up to the present time, and we are safe in assuming that it will remain true until basic conditions have changed or some new method or instrument in commerce destroying is utilized that fundamentally changes the problem.

It may be well to inquire here if there is any property of submarines that indicates that their use as commerce destroyers changes, to any great degree, the general problem of war on commerce as practiced by various nations for a hundred and fifty years. From a superficial examination it would seem as though such were the case, but upon deeper inquiry the effectiveness of the submarine as a commerce destroyer is found to be much more apparent than real. The ability to submerge is an advantage in that it aids in concealment and protection, but at the same time it enormously decreases vision and speed, both very essential for effective commerce destroying.

On account of the physical limitations of submarines they are easily injured or disarranged and a slight injury or disarrangement may be fatal. Compare the relative effect on a submarine and on a fast cruiser of to-day or a fast frigate of the past, of a shot hole, or a steel net or slight disarrangement in motive power, and the limitations of the submarine as a commerce destroyer are at once apparent. The ease with which she may be damaged even by a merchant vessel, very materially limits her ability to board and determine the character of a suspected vessel, and in even moderately heavy weather she is badly handicapped in every way. The size of crew carried by a submarine makes it impracticable for her to send in prizes under prize crews. She can only destroy her prizes. Thus while she can subtract from the wealth of her enemy, she cannot add to that of her own country. A commerce destroyer has always to keep careful watch for two things—her prey and her enemies, to capture the one and to evade the other. To enable herself to evade, the submarine has necessarily to reduce her ability to capture. Certainly up to the present the submarine has not demonstrated that it has changed fundamentally, or even in marked degree, the problem of commerce destroying.

The general non-military opinion as to the effectiveness of the submarine as a commerce destroyer is largely due to the fact that submarine exploits have been considered by the newspapers to have great news value and have been featured because the submarine was a new instrument of war, its employment in commerce destroying was unexpected and its humanitarian side gave to it an interest that its military accomplishments did not warrant.

If financial loss be made sufficiently great and sufficiently widespread to bring suffering or extreme deprivation upon many individuals it may have military effect by damping the general zeal for war or even by arousing a willingness to make great concessions for peace. In the case of the financial losses here considered, we have seen that the very interests that suffer the losses are the ones that to a certain degree have these losses compensated. In this age maritime losses are very generally distributed by means of insurance, and there are no indications of real suffering brought on by maritime losses at sea.

The effect of this form of warfare on the morale of those practicing commerce destroying is, of course, speculative, but it is highly probable that a navy that systematically practices war on defenceless merchant ships almost exclusively for any length of time will deteriorate in those characteristics that distinguish virile, courageous, manly naval personnel. When the French Navy was for so long practicing direct war on English commerce, the morale of her navy was at its lowest ebb. That this was not racial is at once apparent when we recall that during this same time the morale of the French army was above reproach.

We know that heroic action develops the capacity for heroic action, and the development of military character is very largely dependent upon the nature of the service one is required to render.

Though possibly not strictly within the scope of our inquiry, it may be of interest to note that friction with neutrals is one of the historic corollaries of war on commerce. It is not difficult for one warring on the commerce of an enemy to convince himself that an occasional attack on a neutral will produce results of benefit to his country, and such attack is so *easy*, and resistance so futile. Of course, such attacks may be of use in specific instances, but the resulting resentment of the neutral, if nothing more, is bound to react to the advantage of his enemy, particularly if that neutral is of importance in the family of nations. Especially in this day the good will of neutrals is an asset of considerable importance to a belligerent, and war on commerce is a very likely way of alienating such good will.

NOTE.—Various naval authors have been consulted in preparing the first part of the above, particularly Mahan, Darrieus, Daveluy, Corbett and Thursfield.

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# DETERIORATION OF STEEL PROPELLER SHAFTING

By COMMANDER C. H. J. KEPPLER, U. S. Navy

A remarkable instance of pitting of steel shafting after only seven months' service was disclosed recently upon the docking of the U. S. S. *New Orleans* at Navy Yard, Boston. The *New Orleans* is one of the older types of protected cruisers, of about 3400 tons, and is sheathed with copper. About the middle of July, 1917, the installation of new propeller shafts was completed at the Navy Yard, Puget Sound, but the urgent war requirements did not permit encasing the steel shafting with the usual composition sleeve. The tail shafting, a hollow steel forging 13¾″ at its greatest diameter, has a section 30′ 8″ long between the end of stern tube and forward edge of strut bearing, which except for the protective coats of paint was directly exposed to the sea water.

Upon examination in dock on February 16, 1918, the surface of both shafts was found to be covered with innumerable, deep, irregular pits, some areas of from 10 to 16 square inches and from ¼″ to ¾″ deep (see Fig. 1). Near the struts and stern tubes, under the fair-waters, positions nearest the copper sheathing of the hull, were found the deepest and most numerous holes. The steel fair-waters were honeycombed with large holes and the zinc plates had entirely disappeared (see Fig. 1). A black oxidized metallic substance in the deepest pits was removed with scrapers and had the consistency and appearance of soft putty mixed with lampblack. A chemical analysis of this material gave the following:

(a) Ferrous Oxide, 35.3%.
(b) Ferric Oxide, 30.5%.
(c) Loss on Ignition, 16.0%.
(d) Undetermined, 18.2%.

Ferric Oxide is probably FeO to $Fe_2O_3$ after exposure to air. FeO is probably hydrated Ferrous Oxide.

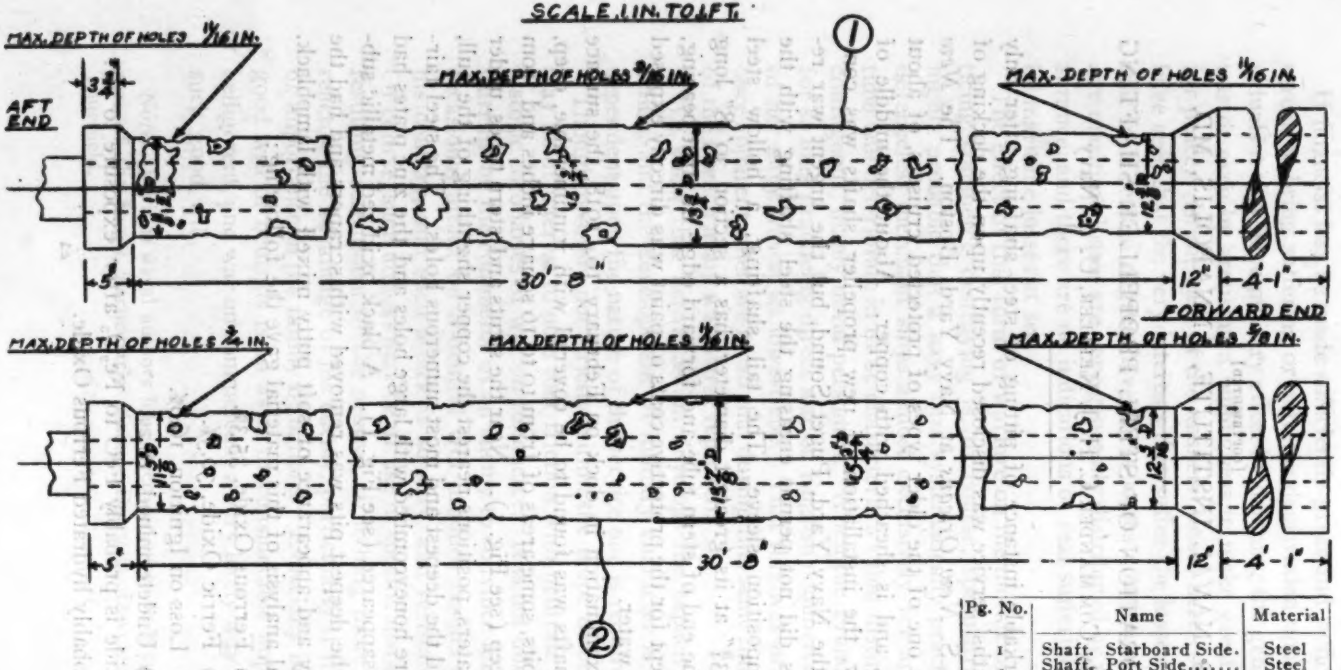


FIG. 1.

| Pg. No. | Name | Material |
|---|---|---|
| 1 | Shaft. Starboard Side. | Steel |
| 2 | Shaft. Port Side..... | Steel |

U. S. S. NEW ORLEANS. PROPELLER SHAFTS SHOWING SURFACE DETERIORATION

Made by C. L..... Checked by C. L..... | Scale 1 in. to 1 ft. Feb. 17, 1918.

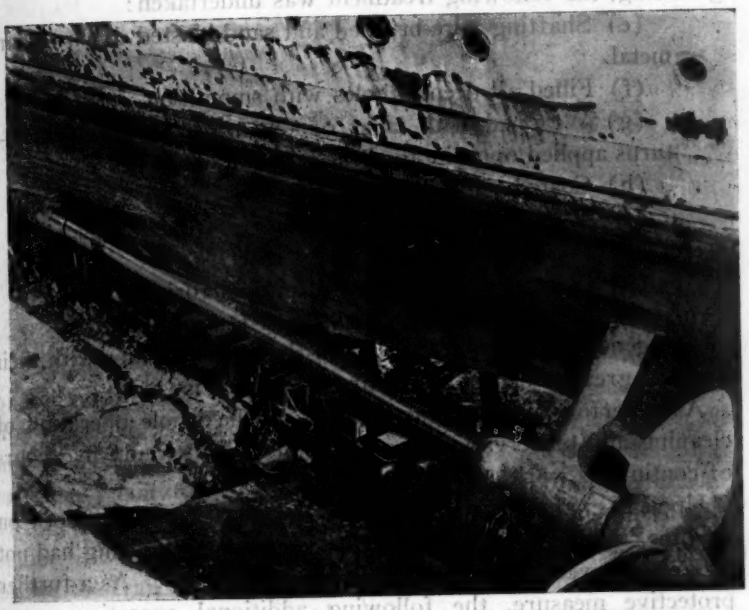

FIG. 2.

FIG. 3.

After consultation by telephone with the Bureau of Steam Engineering, the following treatment was undertaken:

(e) Shafting wire-brushed and sand-blasted down to bare metal.

(f) Filled all deep pitholes with smooth-on.

(g) Wrapped with layer of Okonite waterproof tape—turns applied opposite to ahead rotation of shaft.

(h) Coated with shellac.

(i) Wrapped with layer of adhesive friction tape.

(j) Coated with shellac (see Fig. 2).

(k) Painted with one coat of anti-corrosive paint.

(l) Painted with one coat of anti-fouling paint.

The general dimensions of the tail-shafting, together with their areas of greatest deterioration, are shown in Fig. 3.

As a performance of war emergency, the whole operation of cleaning and preservation was accomplished in twenty-five hours of continuous work.

Upon re-examination of the propeller shafting in dry-dock on 28 June, 1918, it was found that the corrosion and pitting had not progressed over the condition existing in February. As a further protective measure, the following additional operations were carried out:

After the coat of anti-corrosive paint, mentioned under (k) above, the shafts were parcelled with canvas sheeting soaked in tallow. They were then served with housline, taking half hitches every four or five inches so as to prevent unravelling in case the housline was cut at any point; finally a coat of molten pitch and tallow, two parts pitch and one part tallow, was applied to complete the protective jacket.

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# BALL BEARINGS

By LIEUT. COMMANDER H. D. MCGUIRE, U. S. Navy

## PREFACE

"Where do we go from here?" is an expression characteristic of what we of the navy subconsciously are asking ourselves as life unrolls its phase of duties ashore and afloat. Very often we must unceremoniously change from an operating to a designing engineer. Naturally, in such changes we find "nuts to crack." If they are covered by good technical writings we are fortunate; if not, it's a case of dig. That's when we wish some one had blazed the trail with some notes, no matter how meager.

Duty, not long ago, brought me face-to-face with the necessity of determining upon the type of ball bearing to choose for certain high-speed instruments. This was the "nut to crack." From notes made in the investigation of the subject, certain general principles, upon which the theory of ball bearings depends, became apparent, and these are presented in the following paragraphs.

It is understood in a general way that the purpose of the ball bearing is to reduce friction. What else we may expect of it is rather hazy. If the question is asked, "Why are there different types of bearings?", can we answer intelligently? What would be the answer to these questions with reference to ball bearings for a certain machine?

1. Size of bearing required.
2. Type of bearing.
3. Accuracy of bearing.
4. Kind of lubricant.
5. Methods of lubrication.

A little investigation shows that the subject is one that is a profession in itself; consequently, this subject is taken up, not with the idea of writing a treatise on ball bearings, but with the idea of noting certain general principles upon which the theory and practice of ball bearings depend.

## DEFINITION—PURPOSE

A ball bearing is a bearing device consisting of hardened balls and ball paths. (See Sketch 1 for names of parts.) This design reduces friction of motion as compared with ordinary surface bearings, because:

1. Reduction of surface of contact.
2. Bearings consist of accurate spheres rolling in accurate paths.

Surface contact is reduced, as the ball has either two or three points of contact with the races instead of large surfaces in contact.

The reduction of friction, as claimed for accurate spheres rolling in accurate paths, may be illustrated by comparing the friction of running a motor-car on a smooth asphalt pavement (smooth path) with same on mud road (no defined path).

The *friction coefficient* of a well-made annular ball bearing is from 0.001 to 0.0002 of the load referred to the shaft diameter and is independent of speed and load.

The ball bearing, therefore, has the following advantages over plain bearings, viz.:

1. Reduction in friction.
2. More adaptable to high-speed work because of 1.
3. Less vibration because of accuracy.
4. Occupies less space along the shaft.

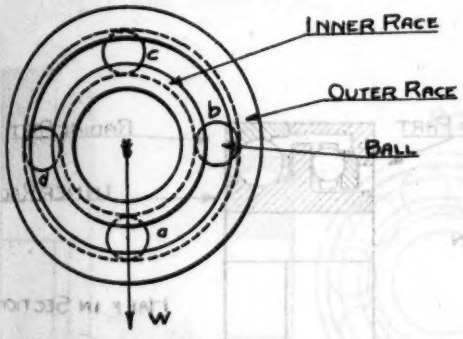
## HISTORY

Ball bearings in modern use date from introduction of the bicycle. This brought in the adjustable cup and cone (three-point contact) type. Under the demands of greater load resistance and reliability the two-point contact type, without adjustability, was evolved for use, carrying loads of from a few pounds to many tons.

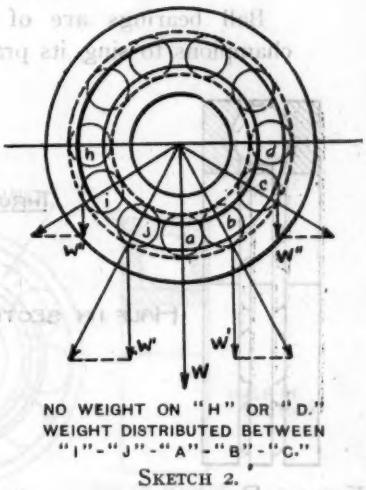
## SIZE OF BEARINGS

The ball diameter determines the size of the bearing. The load a bearing can carry depends upon the size and number of balls and the speed of rotation. Races must be heavy enough to carry the balls at their designed load without deformation.

As the load is taken up between the races by the balls it can be readily seen from Sketches 1 and 2 that the carrying capacity




SKETCH 1.




SKETCH 2.

of the bearing must depend upon the strength of the balls and the number of the balls. This is expressed by formula:

$L = Knd^2$ in which

$= $ Load capacity in pounds.

$n = $ No balls.

$d = $ Ball diameter in $\frac{1}{8}$ of an inch.

$K = $ Varies with the type of bearing; also with material and speed. The radial load up to 2000 r. p. m. is unaffected by speed. Above that speed the radial load sharply increases.

The strength of a ball depends upon its size (diameter) and is expressed by formula:

$W = \frac{1}{4}\pi d^2 S^2 \div E.$

$d = 2\sqrt{WE \div \pi S^2}.$

$S$ = Maximum safe unit stress of material.

$d$ = Diameter of ball.

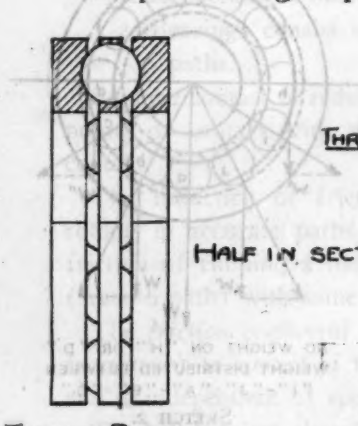
$E$ = Modulus of elasticity.

$W$ = Load.

The strength of a bearing can be increased by increasing the number of rows of balls.

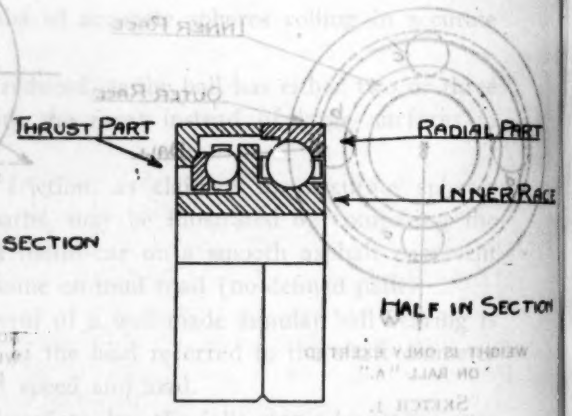
## TYPES OF BEARINGS

Ball bearings are of many types, each of which has its champions to sing its praises. There are certain sound reasons




THRUST BEARING

SKETCH 3.




COMBINED RADIAL AND THRUST BEARING

SKETCH 4.

why there are different designs or types of ball bearings. These may be enumerated as follows:

1. Duties.
2. Method of assembly.
3. Method of ball spacing.
4. Method of alignment.
5. Number of rows of balls.

### DUTIES

The following is the division made according to duties, viz.:

(a) Radial bearings. (See Sketch 2.)

(b) Thrust bearings. (See Sketch 3.)

(c) Combined radial and thrust bearings. (See Sketch 4.)

In radial bearings there can be a slight variance in size of balls, depending on the accuracy required.

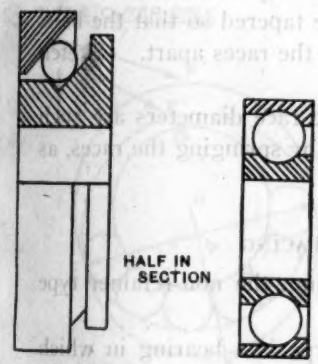
In thrust bearings, variance 0.001" or above in ball diameter seriously affects the bearing, because the whole load is taken up by the large ball, tending to fracture the races at point of contact. Careful selection of balls is consequently essential in this type of bearing.

METHOD OF ASSEMBLY

The following divisions are made according to method of assembly, viz.:

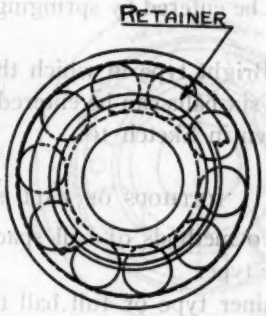
(a) The open type.

(b) The closed type.



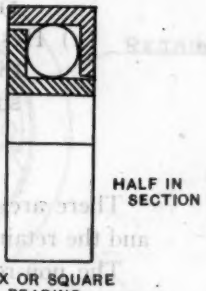

CONE BEARING

SKETCH 5.




NORMA BEARING

SKETCH 6.




BOX OR SQUARE BEARING

SKETCH 7.

The open type bearings are of several kinds, with the principal differences in refinements of retainers, races, etc. The general divisions of this type are:

(a) The box or square bearings, as shown in Sketch 7.

(b) The cone bearing, as shown in Sketch 5.

(c) The retainer bearings, as typified by the Norma bearing. (See Sketch 6.)

The closed type are of several kinds, the difference being in method of filling balls in races. The general divisions under this type are:

(a) Slotted (interrupted race), and

(b) Non-slotted type (uninterrupted race).

The slotted types (interrupted race) are of two kinds, viz.:

(a) One race slotted. (Sketch 9.)

(b) Both races slotted. (Sketch 8.)

These types may be either full ball or retainer types. This type of bearing cannot take end thrust, as balls tend to ride over slot edges; and this type cannot be disassembled without tending to wear the slots into the ball paths.

The constant for the carrying capacity of bearing with one race slotted is $K=5$, 2000 r. p. m. in formula $L=Knd^2$.

The constant for the carrying capacity of bearing with both races slotted is $K=2.5$, 2000 r. p. m. in formula $L=Knd^2$.

The non-slotted (uninterrupted race) types differ in design in the method of filling, and are divided into three principal types:

(a) *SKF* self-aligning bearing filled by means of retainer.

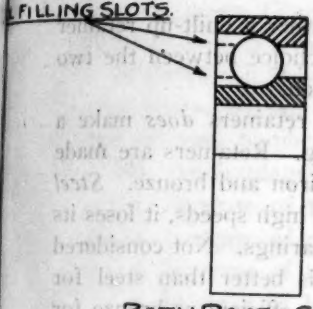
(b) Fafnir type in which races are tapered so that the balls may be entered by springing the races apart. (Sketch 11.)

(c) Hess-Bright type in which the race diameters are such that six balls can be entered by springing the races, as shown in Sketch 10.

### METHODS OF BALL SPACING

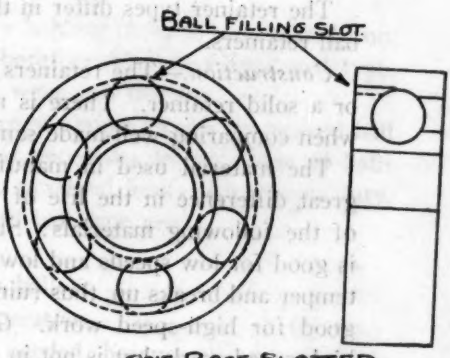
There are two methods of ball spacing, the non-retainer type and the retainer type.

The non-retainer type or full ball type is a bearing in which centrifugal force is depended upon for spacing the balls. In this type the race is filled with balls, so that there is a space of about one-fourth (¼) the ball diameter between any two balls when they are forced apart. Centrifugal force tends to keep the ball spaced when the bearing is in operation at high speed; but, due to there being no retainer to cushion balls and reduced vibration, this type is noisier than the retainer type. It is generally considered that this type of bearing is undesirable for high-speed work where great accuracy is necessary, but in actual practice this type is efficient; examples, torpedo gyro, Sperry gyro-compass, Fafnir bearing. It makes a better bearing for slow speeds with great weight, for according to the formula for carrying capacity of a bearing, it will be noted that the greater the number of balls the greater the carrying capacity of the bearing.



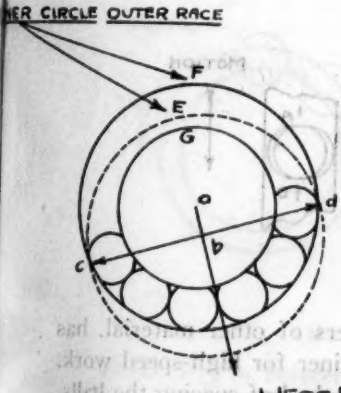

BOTH RACES SLOTTED

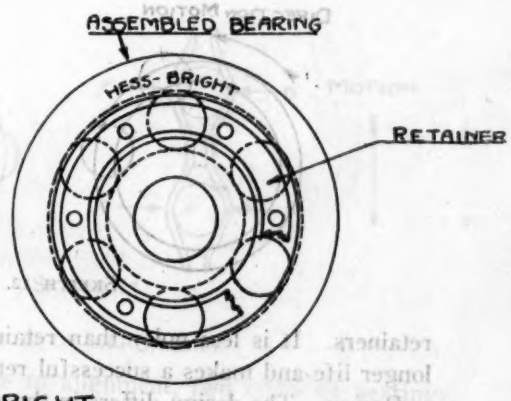
SKETCH 8.




ONE RACE SLOTTED

SKETCH 9.

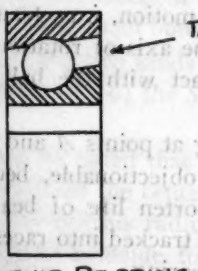



HESS BRIGHT

SHOWING MOVEMENT OUTER RACE TO ALLOW BALLS TO BE INSERTED IN RACES.

SKETCH 10.



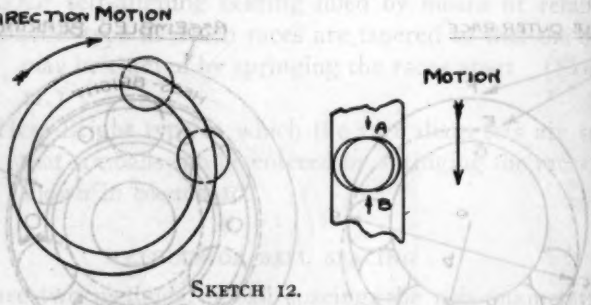

FAFNIR BEARING

SKETCH 11.

The retainer types differ in the design and construction of the ball retainers.

*Construction.*—The retainers may be either a built-up retainer or a solid retainer. There is not much choice between the two when comparing well-made samples of each.

The material used in manufacture of retainers *does* make a great difference in the life of the bearing. Retainers are made of the following materials: Steel, grey iron and bronze. *Steel* is good for low speeds and low heat. At high speeds, it loses its temper and breaks up, thus ruining the bearings. Not considered good for high-speed work. *Grey iron* is better than steel for high-speed work, but is not in any way as efficient as bronze for high-speed work. *Bronze* is considered the best material for




SKETCH 12.

retainers. It is less noisy than retainers of other material, has longer life and makes a successful retainer for high-speed work.

*Design.*—The design differs in the method of spacing the balls. To space the balls, the retainers must touch the balls at some point or points. All points on the surface of the balls traveling about the race have either motion of translation or motion of rotation, or both. The axis of the ball at right angles to the plane of the race (plane of translation) has but one motion, *i. e.*, translation. Therefore a retainer touching only at the axis of rotation of the ball will cause less friction from contact with the ball than a retainer touching at any other point.

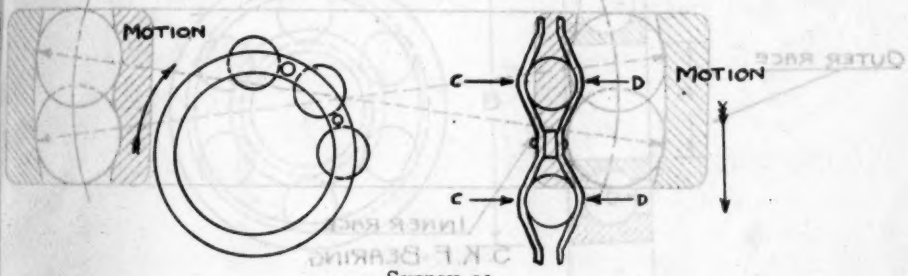
The type that spaces balls by touching at points *A* and *B*, *i. e.*, points other than axis of rotation, is objectionable, because it causes friction (heat) and tends to shorten life of bearing by wearing retainer, the particles of which, tracked into races by the balls, destroys the concentricity of the bearing.

The type that spaces balls by holding them at axis of rotation, *i. e.*, at points *C* and *D*, is, therefore, the most approved type, because there is a minimum of wear and friction.

In general, it is better, if design allows, to use the spaced ball type instead of full ball type; if necessary, increase size of balls and decrease number to within practical limits to perform duty.

The disadvantages of the full ball type are:

1. Increase of friction.
2. Increase of cost (more balls).
3. Increase of noise of operation.
4. Increase of lubrication needed, because there is nothing to retain the oil in contact with balls, as in case of retainer bearing.




SKETCH 13.

## METHOD OF ALIGNMENT

There are, in reference to alignment, two types of bearings, viz., the non-aligning and the self-aligning bearings.

The non-aligning bearings are the ordinary types of bearing whose races must be in the same plane to operate without binding.

The self-aligning bearings are the types of bearings which allow certain freedom of movement of the races independent of each other without binding.

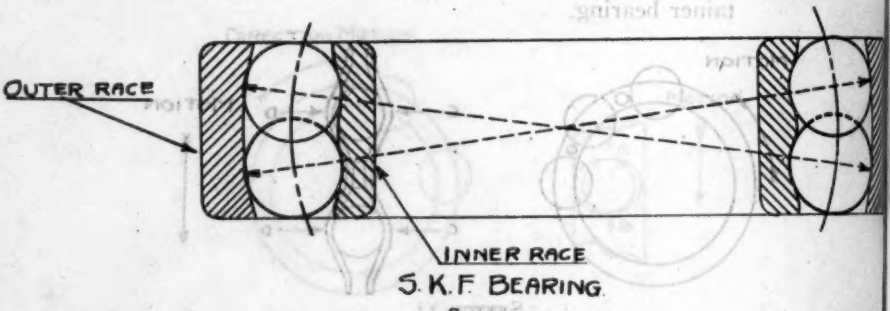
There are two kinds of self-aligning bearings: (a) Cone and cup type; and (b) the *SKF* type. (See Sketch 5 for cone and cup type.)

It will be noted that outer race of *SKF* bearing is ground on a radius from the center of the bearing and the balls ride on the inner race on this radius so that the planes of the two races do not have to coincide for proper operation. Of these two types the *SKF* is the better. It does not have to be adjusted for ball

clearance when installed and is a successful high-speed bearing. Generally speaking, the cone and cup type of bearing is not considered a good bearing, because of frictional resistance of three-point contact and difficulty in making accurate adjustment of bearing on the shaft.

### NUMBER OF ROWS OF BALLS

In order to increase the carrying capacity of bearings without increasing the size of the bearing radially, the multiple race type is adopted. For practical purposes the races are seldom more




SKETCH 14.

than doubled, because of increase of frictional factor and the practical difficulty of manufacturing double races exactly similar; for over-sized balls, or races out of parallel, throw whole weight on one side.

*Accuracy.*—The accuracy of the bearing depends on the accuracy of the balls and races.

*Balls.*—Balls for ordinary commercial work are accurate to

| | |
|---|---|
| Grade "A" | 0.0025" in diameter. |
| Grade "B" | 0.001" to 0.002" in diameter. |
| High duty or special | 0.0001" to 0.00005" in diameter. |

*i. e.*, the difference between the greatest diameter and the least diameter.

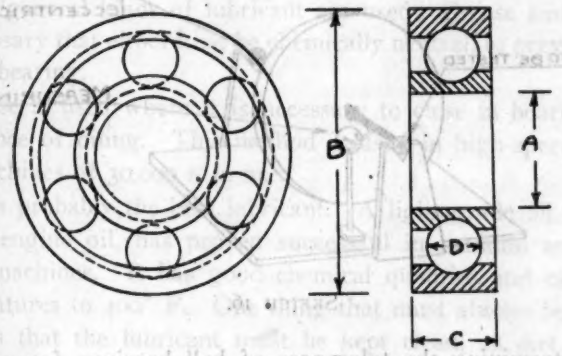
*Races.*—The accuracy of races or completed ball bearings for ordinary commercial work are from 00.0015" to 0.00015" eccentricity.

## ACCURACY OF BEARINGS

By tolerance in bearings we mean the measured variations allowed in bearings. The dimensions are as shown in Sketch 15. The tolerances in these measurements would be expressed as plus or minus so many thousandths or hundredths of an inch or millimeter, as the case may be.

These measurements can be made accurately by plug gages and snap gages.

*End Play.*—By rigidly securing the outer race the movement of the inner race in line with the bore can be measured. The




SKETCH 15.

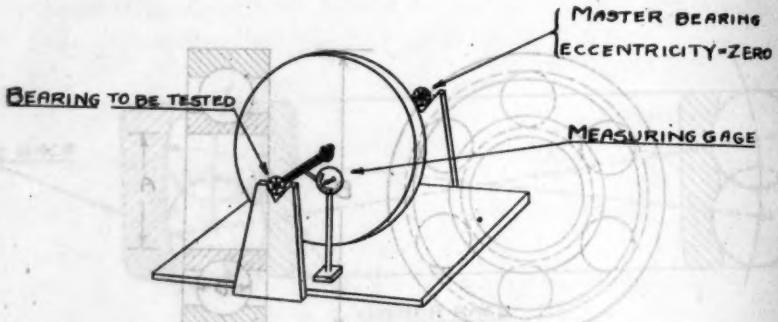
A = Bore.
B = Outside diameter.
C = Width of bearing.
D = Ball diameter.

tolerance for end play must depend upon duty to be performed. For instance, the bearings of a gyroscope should not have any end play, as end play would change the horizontal balance, while end play of a few thousandths of an inch would not make any difference in a generator.

*Eccentricity.*—By placing a bearing in a measuring machine, such as is shown in Sketch 16, the total movement of the shaft caused by the inequality of the races and balls of the bearing being tested will be indicated by the movement of the needle of the measuring instrument. The total movement of the needle

during a complete revolution of the shaft is the eccentricity measured in thousandths or ten thousandths, as the case may be.

There are bearings of all degrees of tolerances on the market from poorest grade bearing, such as is used in baby carriage wheels, to the highly specialized bearing, such as is used in gyroscopic wheels. The degree of perfection is also an indication of the price, so that it behoves the designer to get the proper bearing for the work; *i. e.*, be satisfied when he gets a bearing that runs smoothly and does not wear out quickly.




SKETCH 16.

In determining the tolerances of ball bearings for a certain machine, bear in mind the following:

1. Avoid vibration, as it shortens life of bearing.
2. Vibration is caused by inaccuracies of races or balls.
3. Vibration is caused at high speed by dynamic unbalance of the load.
4. That perfect bearings will vibrate with load dynamically unbalanced.
5. With inaccurate bearings, the higher the speed the greater the vibration.
6. That the proof of the selection is a smooth running bearing.
7. The life of a bearing depends on the quality of the races, balls and retainer—a breakdown in any one of which will destroy the bearing.

## KIND OF LUBRICANT

Oil is the greatest friend, and dirt the greatest enemy of the ball bearing.

The lubrication of a ball bearing is absolutely necessary. A thin film of oil has by practice given the best results. Too much oil causes friction, but the heat is carried off by the oil and immediate bad results do not arise from this source. The main objection to too much oil is that the oil becomes broken down rapidly, thus losing its lubricating qualities, which entails loss of money and labor. Too little oil results in friction and damage to bearing by over heating.

Two general kinds of lubricant are used: Grease and oil. It is necessary that either kind be chemically neutral, to prevent rusting of bearing.

Grease is used where it is necessary to close in bearing with no chance of oiling. This method is used in high-speed grinding machines of 30,000 r. p. m.

Oil is probably the best lubricant. A light grade oil, such as Arctic engine oil, has proven successful in medium and high-speed machines. It has good chemical qualities and can stand temperatures to 400° F. One thing that must always be kept in mind is that the lubricant must be kept clean, as dirt reduces life of bearing.

## METHODS OF LUBRICATION

There are many methods of lubrication. With grease in use the bearing is packed in grease. With oil lubrication the lubricant is transferred to the bearing by surface attraction (wick method), by splash or by oil rings.

The wick method is the most efficient, as the oil flow can be accurately determined by the number of strands in the wick and all oil reaching the bearings is filtered. The wick should not touch the moving parts of the bearing, otherwise the filtering feature is destroyed, as lint would be carried into the bearing.

Oiling rings and splash system have two disadvantages: Firstly, they break up the oil, thus shortening its life; and secondly, they do not filter the oil and tend to flood bearings with oil sediment and chips from oil rings.

## SUMMARY

In summation, the points to be borne in mind in reference to choice and use of bearings are:

1. A ball bearing has less friction than ordinary bearing.
2. Two-point contact bearing best.
3. For high speed use retainer type bearing.
4. For low speed, heavy load, use full ball type bearing.
5. Slotted type bearing objectionable where there is end thrust.
6. Double or multiple row bearings not so satisfactory as single row bearing.
7. Use bearings with 300 or 400 per cent safety factor.
8. A well-made bearing of good material will give a long life.
9. The tolerance of bearing must be determined by the amount of vibration allowable.
10. Long life for high-speed bearings depends on load and accuracy of bearing.
11. Radial bearings should not be subjected to more end thrust than 10 per cent of designed load capacity.
12. Use self-aligning bearings where perfect alignment is not essential.
13. Lubrication of ball bearings is necessary.
14. Too much oil is better than too little oil.
15. Wick oiling best.

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# THE ELECTRICAL DIVISION ABOARD SHIP

By LIEUT. COMMANDER ALEX. M. CHARLTON, U. S. Navy

The electrical division aboard ship has grown, like Topsy, without much fathering or mothering until very recent years. It is the purpose of this article to trace the growth of the electrical personnel aboard ship from its beginning to its present organization, which is believed to be the logical and ideal one for the proper performance and upkeep of the electric plant.

Electricity for lighting purposes was first introduced on a man-of-war in 1883, when the U. S. S. *Trenton* was equipped with an Edison lighting plant. Before this time electricity supplied by batteries had been used for call bells and annunciators, and small hand-generating sets for the firing of torpedoes (mines) and guns. The power of these devices was, of course, negligible.

The dynamo of the *Trenton* was installed at the navy yard, New York, under the cognizance of the Bureau of Navigation, although the Bureau of Ordnance agreed to pay half the cost of the labor and material to fit the dynamo engine with steam and exhaust piping. The cognizance of the Bureau of Navigation over electrical apparatus was established even before electric lighting had been installed on any naval vessel.

> It (the Bureau of Navigation) shall furnish signal lights, running lights and standing lights on board vessels, including electric apparatus for lighting purposes.—General Order 293, March 30, 1882.

The rating of electrician was established in November, 1883, shortly after the *Trenton's* plant was completed, at a rate of pay of $50 per month. (General Order 310, November 17, 1883.) After being in existence two months, however, the rating was abolished (General Order 315, January 5, 1884).

As men trained for seamen gunners at this time received instructions at the torpedo station, Newport, in electrical matters, it was apparently decided that a special rating was not necessary for the upkeep of the plant on the *Trenton*. The engine and dynamo of this plant were very ruggedly built and required little attention. Reports made during the year following their installation say nothing of engine or dynamo trouble.

The office of Naval Inspector of Electric Lighting was established in January, 1887. Lieut. Commander R. B. Bradford was the first inspector. He had performed much the same duty for some time previous, and as executive officer of the *Trenton* had supervised her installation.

During this early period, while dynamos were being installed for lighting purposes by the Bureau of Navigation, the Bureau of Ordnance was also installing dynamos for use with searchlights. The searchlights were operated from series-wound machines giving about 50 volts, and the incandescent lamps from shunt-wound machines giving various voltages from 70 to 110. With the introduction of the compound-wound dynamo, both searchlights and lamps could be operated from the same machine. The divided cognizance (ordnance and navigation) brought in various types of dynamos, engines and appurtenances, and it soon became apparent that one bureau should have the cognizance of all electrical material.

This was done in 1889 when the Bureau of Equipment and Recruiting was given cognizance of all electric appliances aboard ship.

The responsibility for the care, preservation, efficiency and working of all electric apparatus on board ship rested with the navigator. He had seaman gunners and gunners' mates to stand watch on the dynamos and repair the circuits. These men were given a certain amount of instruction in electricity at Newport, but they did not specialize in that subject.

The need for specially trained men became apparent as electricity was extended to other uses besides lighting, such as signal sets, interior communication and telephone.

On account of the steadily increasing demands upon the electric plant of a ship and its consequent extension to meet the requirements, the care and attention necessary for efficiency is also growing. In view of this fact, it is respectfully recommended that the rate of electrical machinist be

established with adequate pay that will compensate and attract suitable persons, and that the rating be open to any enlisted man who possesses the necessary qualifications.—Report of Naval Inspector of Electric Lighting, 1890.

This recommendation was continued without success, however, until 1898, when the ratings of chief electrician, electrician 1st class, and electrician 2d class, were established, with monthly rates of pay of $50,45 and $35, respectively.

Even in the early nineties it was believed that an officer should be in charge of the electric plant, and the midshipman aid to the navigator was sometimes given charge of the installation. As he frequently had no more than the most rudimentary knowledge of electrical principles, his supervision amounted to little. So the plant limped along under the gunner's gang, which consisted of men with little or no theoretical knowledge. With engines and dynamos which were rugged and required little upkeep, and with the only apparatus outside the dynamo room consisting of lamps and call bells, this organization was able to keep the apparatus working.

With the introduction of motors aboard ship, the situation was changed, and we find in the report of the Naval Inspector of Electrical Appliances (1898):

As the electric plant of the modern battleship has increased to such an extent that it requires the constant superintendence of an officer, I have to recommend that this duty be assigned to a junior officer who can devote his whole time and attention to the care and preservation of the plant.

And in 1899 the chief of the Bureau of Equipment (Admiral Bradford) recommended to the Secretary of the Navy:

It is respectfully urged that the time has arrived when it is necessary to detail a larger staff to take charge of electrical appliances on shipboard. At least one lieutenant and a warrant officer, in addition to a number of petty officers, should be exclusively employed for this duty as in foreign navies. At present no officer is detailed for this duty alone. The power now developed in the larger ships is . . . . almost equal to that developed by the motive steam machinery in the ships 30 years ago, when a large staff of engineer officers and others were thought necessary for its care. In addition, the appliances used in electrical installations are delicate and require a high order of intelligence and technical knowledge.

It was at this time that the *Kentucky* and *Kearsarge* were being built with 350 kilowatts generator capacity, and electrical appliances calling for 661 kilowatts. These appliances in-

cluded turret motors, ammunition hoists, boat cranes, deck winches and ventilating motors. In addition to there being this great amount of new gear, the ship had a rather complicated three-wire system for distributing current.

The Bureau of Equipment was much concerned with the constantly increasing demands for repairs and renewals to the electrical outfits of ships. Ships were not long self-sustaining electrically without extensive dockyard work. After the abandonment of the course in electricity for officers at the torpedo station, all official progress towards educating officers in electrical matters ceased. No instruction of practical value was given at the Naval Academy, and we find battleships going into commission with extensive electrical plants and no skilled personnel to care for them.

In 1899, schools of instruction were started. The course for officers was re-established at Newport, and a school for enlisted men at the navy yards in New York and Boston. The following year the school at Boston was discontinued, and a school established at Mare Island. These men were taught the rudimentary principles of electricity and had practical work with electrical machinery, in addition to work on ships under repair. Most of these men when they finished the course of instruction were eligible for rating as third-class electricians. The course for officers, held during the summer, was of an elementary character and merely touched on a variety of electrical subjects.

In 1900, it was recommended that the grade of warrant electrician be established and that warrant electricians be assigned to duty in connection with electric plants of battleships and armored cruisers.

Nothing was done toward creating a grade of warrant electricians until 1912. In that year, candidates for gunner were divided into two classes: those fitted to specialize in ordnance and those fitted to specialize in electricity. Before this time (as early as 1905) electricians had been warranted as gunners, but no effort was made to detail them for electrical duty only. There is no doubt that the warrant rank of electrician and chief electrician should be established. The present rate of electrician should then be changed to that of electrician's mate to conform to other ratings in the service.

Until very recently the electricians have not been gathered together in an electrical division. Watch bills of ships in commission during the last 20 years generally show the electricians assigned to the powder division, although sometimes they were put in the navigator's division, and sometimes split up among the various deck divisions.

As the powder division was made up of odds and ends of the complement who were put there because of their stations at general drills, no particular attention was paid to the electricians as electricians. The powder division officer had no cognizance of the electrical machinery, and his only interest in electricians consisted in mustering and inspecting them. The navigator was too busy with his other duties to pay much attention to electrical matters, and the efficiency of the plant depended on the gunners. Neither the gunner nor the electricians were skilled mechanics, and there was usually friction when it came to getting work done by the engineer's force on the dynamos and dynamo engines. So the electricians renewed gaskets, packed valves and fitted bearings as well as they could most of the time, rather than call on the engineer department. It is astonishing that the plants held together as well as they did.

The establishment of the postgraduate school at Annapolis in 1909 opened the way for the navy to obtain officers with special electrical training. Although it was stated at the time of the establishment of this school that its object was the obtaining of designing engineers and not operating engineers, yet there is no doubt in the service that the gradual outflow of electrical engineers from the postgraduate school has helped and will help the efficiency of our electrical machinery.

The navigator remained in charge of the electrical plant aboard ship until 1911, when correction No. 15 to the 1909 regulations was published. By this "the ordnance officer is the officer detailed by the department to have supervision over and be responsible for . . . . the electrical installation under the cognizance of all bureaus outside the dynamo rooms, including the wireless telegraph outfit. His responsibility as to the care, preservation and efficiency of the electrical installation begins at the dynamo-room bulkhead and embraces all electrical apparatus fittings and appliances outside the dynamo rooms." At the same time the senior engineer officer was made "responsible for the preserva-

tion and efficient working . . . . of the dynamo engines, generators and appurtenances, including all electrical apparatus and accessories contained within the dynamo rooms."

This change was brought about by continued demands of the electrical force upon the engineer department for repairs and overhaul of the dynamos.

The electricians were not competent to make proper repairs on the dynamos and each item of work had to be handled by a request of the navigator to the engineer officer.

The engineer officer did not want to transfer machinists to the navigator's division (when there was one) or to the powder division. The simplest way out seemed to be to transfer the dynamos and their auxiliaries to the engineer department and make them part of the auxiliary division in that department.

At the same time, it seemed best to transfer the electrical machinery outside the dynamo room to the ordnance officer, as he had a particular interest in much of this machinery. The turrets were trained and guns elevated by motors, ammunition was hoisted by electricity, and the fire-control installation with its telephones, range and deflection visuals, battle order indicators, etc., began to increase in size and importance. It was felt that, with gunnery efficiency dependent absolutely on electrical efficiency, the gunnery officer would take measures to achieve the latter.

This division of cognizance aboard ship, however, did not work out in an entirely satisfactory manner. The auxiliary machinists usually had little or no knowledge of electricity and, while repairs to the steam machinery were made efficiently enough, the generators and switchboards were not sufficiently well cared for.

The duties of the ordnance officer were sufficiently arduous from a strictly gunnery point of view without putting upon him the burden of responsibility for a power plant of great diversity. He had no time for the supervision of an installation which well could take the whole time of an officer trained in electrical matters. His primary interest, naturally, was in the gunnery electrical gear, and the remainder of the plant, such as lighting-circuits, winches, cranes, steering gear, blowers, etc., was a matter of secondary importance.

The usual method of handling the situation was to turn the plant over to the electrical gunner and require him to "fix it."

On some ships there was a fire-control officer who looked out for the electrical fire-control circuits.

All of these assignments of cognizance were but evasions of the early recognized and often recommended principle that the electrical installation of a modern ship demanded the exclusive services of an experienced commissioned officer.

There was no division loyalty and *esprit de corps* among the electricians such as there is in the deck divisions. There was constant friction between the dynamo electricians and the remainder of the electrical force. There was no division officer to whom the electricians could go; no one who "spoke the same language" and would see that their interests were taken care of.

There were two paramount reasons during this time (1911-14) for not detailing officers aboard ship for electrical duty only: the first was a lack of officers specially trained in electricity, and the second was a general deficiency of commissioned personnel in the service, due to new ships going into commission and to increased demands for officers on ships already in commission.

Having in mind the above-mentioned difficulties, the commanding officer of the *Texas,* when she was first commissioned in 1914, organized the electricians as a part of the engineer department. An electrical postgraduate had inspected the electrical machinery during its installation and was detailed by the commanding officer as electrical officer when the vessel was commissioned.

In January, 1916, Mr. Frank J. Sprague, the eminent electrician, spent three weeks on the U. S. S. *New York.* In a report to the Secretary of the Navy, he made the following comment:

> The electrical equipment of a ship is now so complicated, and its operation and the handling of its guns so dependent upon electricity, that there should be on every first-class ship an officer who is a specialist in that scientific branch; one who might be designated as the chief electrical officer or electrical chief, as distinguished from the terms electrical engineer or electrician, which are oftentimes misused. At present the electrical knowledge is more or less divided between the ordnance officer, gun captains, electrical gunner and electricians of the ship; that is, between commissioned and warrant officers and enlisted men. It would be far better if a commissioned officer who has made a specialty of the subject were given a complete supervision and responsibility with regard to electrical equipment.

In a memorandum to the secretary, the Bureau of Steam Engineering made the following comment on the above statement:

The bureau heartily endorses this recommendation. At present, the senior engineer officer and the gunnery officer of a ship divide responsibility for maintenance and operation of the electric plant. Both officers have multitudinous duties, and many parts of the installation do not directly affect the efficiency of the department of either officer. The latest ships have an electrical officer whose sole duty is the care of the electric plant; but this officer is merely detailed by the captain, and by naval regulations has no standing. The position should be made official and should be made subordinate to senior engineer. This is the case on the *Texas*, whose electric plant is, so far as the bureau knows, the best handled in the fleet. The bureau in the past has received very little help from the fleet in improving electric installations, because there has been no one charged exclusively with such installations, who took the interest to make suggestions.

The subject of electrical organization aboard ship was referred to the fleet and there was no doubt expressed concerning the necessity for an electrical officer on battleships. The consensus of opinion favored the electrical officer being a subordinate of the engineer officer, and in August, 1916, the regulations were changed to incorporate the following:

Par. 2826 (R):

1. The electrical officer shall be an assistant to the senior engineer officer. He shall be charged with the maintenance, care, and preservation of all electrical appliances installed on the ship, including radio and fire-control appliances and other electrical signal apparatus; to this end the electrical gunner and all electricians attached to the ship shall be subject to his orders so far as maintenance, care and preservation of all electrical appliances are concerned.

2. He shall, through the proper channels, make recommendations to the Navy Department concerning any alterations in methods or in the apparatus or installation of new devices which will contribute to increased efficiency or economy of the electric installations.

3. He shall have the custody of the record of electrical appliances and all plans relative to the electric installation, supervise the keeping of the electric log, make the routine reports required by the Naval Instructions, make lists of repairs needed, and keep all records of electrical work done.

4. He shall be charged with conducting all tests of electric apparatus called for by the Navy Department, and with the making of reports thereon.

5. When fitting out he shall make a thorough inspection of the entire electric outfit of the ship, including spare parts and fittings, stores and supplies. He shall also carefully inspect all electrical storerooms, workshops and other space intended for electrical equipment or supplies. Should

he discover any defects or deficiencies he shall immediately make a detailed written report of the facts to the commanding officer.

The history of the electricians on board ship has been reviewed in detail to show how long it has taken to reach the logical assignment of the electrical personnel.

The organization, routine, tests, etc., developed on the *Texas* is given below. This organization has been in effect practically without change since the *Texas* was commissioned in 1914. It is very flexible, permitting the ultilization of men on work for which they are best fitted and also permitting the concentration of any needed number of men upon any emergency or repair job without going outside the division.

## ELECTRICAL DIVISION, U. S. S. *TEXAS*—ORGANIZATION, ROUTINE AND TESTS

1. The electrical division of the engineer department consists of all the general electricians assigned to the ship, and a sufficient number of machinist's mates and firemen to make repairs upon and stand watch over the turbines and auxiliaries.

2. The electrical division has cognizance of and makes repairs upon all electrical machinery of the ship, including the turbo-generators, all motors, telephones, fire-control circuits, storage batteries, interior communication circuits and gyro-compasses.

3. The complement of the electrical division is as follows:

| | |
|---|---|
| | Electrical officer. |
| | Electrical gunner. |
| 3 | Chief electricians. |
| 10 | Electricians, 1st class. |
| 10 | Electricians, 2d class. |
| 10 | Electricians, 3d class. |
| 1 | Chief machinist's mate. |
| 2 | Machinist's mates, 2d class. |
| 4 | Firemen, 2d class. |
| 5 | Firemen, 3d class. |
| 7 | Deck division strikers. |
| 1 | Engineering division striker, fireman, 3d class. |
| 53 | |

One electrician is detailed as storeroom keeper in the supply department from the above complement.

The deck division strikers have billet numbers in the electrical division, mess with the electricians, muster with the electrical division and stand bag and hammock inspection with the electricians. They are considered to be electricians in training, and do duty as electricians with the exception of

general quarters and coaling ship, where they work with the divisions from which they were detailed.

4. The division is divided into five units, each in charge of a chief petty officer. These units are as follows:

P1 Dynamo watch.
P2 Lighting and workshop.
P3 Power and searchlights.
P4 Interior Communication and fire-control.
P5 Dynamo repair.

These units are further subdivided into four sections to conform to the section arrangement of other divisions.

5. The duties of the various units are as follows:

*Dynamo Watch.*—This unit stands watch on the running dynamos and the ventilating blower motors throughout the ship. A first- or second-class electrician is on watch in the running dynamo room, with a fireman, 2d class, to look out for the turbines and auxiliaries. In the idle distribution room is a second- or third-class electrician and in the running distribution room a striker who makes the rounds of the ventilating blower motors once an hour. The dynamo watch is responsible for the cleanliness of the compartments assigned to the electrical division, except the workshop, storeroom, telephone repair shop and battery locker.

COMPLEMENT

1 Chief electrician.
2 Electricians, 1st class.
4 Electricians, 2d class.
2 Electricians, 3d class.
4 Firemen, 2d class.
4 Strikers.

A watch in four is stood in the dynamo room.

*Lighting and Workshop.*—This unit has cognizance of all lighting and battle lighting circuits, except the magazine lights, including navigational and signal lights, and also the galley ranges and bakeshop ovens and the motors of the galleys. The lighting circuits are divided into: Gun and and half-deck forward; gun and berth deck aft; bridge and upper decks; and fire and engine rooms. An electrician is detailed for work in the workshop and to look out for the storeroom. A striker from the engineer's force is detailed to assist on the fire- and engine-room circuits. The electricians on the lighting circuits also look out for the room and desk fans.

COMPLEMENT

2 Electricians, 1st class.
4 Electricians, 2d class.
1 Striker.

The chief electrician of the dynamo watch also has charge of this unit unless there is a chief electrician on board in excess of the complement, when he is put in charge.

*Power and Searchlights.*—This unit has charge of all power and ventilating blower motors, searchlights, storage batteries and the electrical work in the power boats. The various motors and searchlights are divided among the electricians assigned to this unit for cleaning, testing and repair. A third-class electrician is assigned to each turret. He has charge of the motors and lighting circuits in the turret and magazines, and looks out for the 5-inch ammunition hoists assigned to him. He is required to carry out the routine of cleaning, testing, making insulation tests, etc. All repairs in the turrets are supervised by the chief electrician in charge of the unit. Each searchlight has an electrician in charge, both for cleaning and testing, and for operating during night torpedo defence quarters.

COMPLEMENT

1 Chief electrician.
3 Electricians, 1st class.
7 Electricians, 3d class.
2 Strikers.

*Interior Communication and Fire-Control.*—This unit has cognizance of all interior communication circuits, ship's service telephones, gyro-compasses, fire-control telephones and instruments and firing circuits up to the locks of the guns. This includes the director system for the main battery and the sight lighting for the 5-inch guns and the range-finders.

COMPLEMENT

1 Chief electrician.
3 Electricians, 1st class.
2 Electricians, 2d class.
1 Striker.

*Dynamo Repair.*—This unit consists of the machinist's mates and helpers, who make all repairs on the turbines and dynamo auxiliaries. The plants are run a month at a time, approximately; the two machines in one room taking the load on alternate days during the month. During the month the idle plant is given a thorough overhaul. As a rule, only such repairs as can be finished during working hours are undertaken in any one day, both plants being ready to run during the night, if necessary. The machinery of the idle plant is turned over under steam each week and all emergency devices tested.

COMPLEMENT

1 Chief machinist's mate.
2 Machinist's mates, 2d class.
2 Firemen, 3d class.

### DUTIES OF THE DIVISION AT GENERAL DRILLS

*General Quarters.*—The dynamo watch reports to the dynamo rooms; starboard watch to the after dynamo room; and the port watch to the forward dynamo room. The lighting unit is divided between the forward and after repair parties. The power unit furnishes men for the repair parties; the turret electricians report to their turrets; one electrician goes to the steering motor room and one to the forced draft blowers. The I. C. and F. C. unit mans the I. C. room and the plotting room switchboards; one man is in the central station standing by the gyros, and one with gunnery officer. The chief electrician tends the fire-control switchboards. The dynamo repair unit is divided between the dynamo rooms. The deck strikers go to their gun stations.

*Night Torpedo Defence Quarters.*—The dynamo watch and the dynamo repair units go to the dynamo rooms. The lighting unit stands by the battle lanterns and battle circuits. The power unit mans the searchlights. The I. C. and F. C. unit is divided among the 5-inch guns to look out for buzzers and sight lighting. Deck strikers go to their gun stations.

*War Watch.*—The dynamo watch stands regular watch. Lighting unit stands by for calls. The power unit mans two searchlights. I. C. and F. C. unit stands a trouble watch on the bridge. The dynamo repair unit sleeps in the idle dynamo room.

*Fire.*—The idle plant is manned and gotten ready to start up if necessary. Men on watch in the distribution rooms cut out ventilating blowers supplying compartments in the vicinity of the fire. The lighting, power, I. C. and F. C. and radio units fall in at quarters. One electrician reports to the first lieutenant at the scene of the fire.

*Collision.*—The dynamo watch and dynamo repair third and fourth sections stand by to start the idle plant. The lighting unit falls in at quarters. The third and fourth sections of the power unit mans the boat cranes, deck winch, capstan and the dynamo trunk hatches. The I. C. and F. C. unit closes water-tight doors and then falls in at quarters. The third and fourth sections are used for above duties, as they are the last to leave the ship.

*Abandon Ship.*—The division abandons ship as follows:

| | |
|---|---|
| First section | First motor sailer, first trip. |
| Second section | Second motor sailer, first trip. |
| Third section | First motor sailer, second trip. |
| Fourth section | Second motor sailer, second trip. |

The third and fourth sections of the dynamo watch and dynamo repair units man the dynamo rooms until second party is about to leave ship. Dynamo watch remains in the dynamo rooms until the ship is abandoned, escaping up the trunks. The cranes, deck winch and capstan are manned by the third and fourth sections of the power unit until they are no longer required.

## ROUTINE, INSPECTIONS, TESTS AND REPAIRS IN DIVISION

### DAILY

*Dynamo Station*

Test insulation on lighting and searchlight circuits.
Jack over spare generator armature.
Inspect all stations.
Test auxiliary lighting circuits.
Inspect recording ammeters.
Test signals for interlocking circuit-breakers relay.
Inspect dynamo room exhaust blower motors.
Check up dynamo log sheets and get out data.
Make up work sheet and write up work book.
Inspect running generators.
Inspect all blowers hourly.
Clean switchboards.

*Lighting and Shop Station*

Inspect and check up daily insulation book.
Make up work sheets and write up work book.
Inspect all lighting circuits for burned out lamps, blown fuses and low insulation.
Inspect galley and bakeshop ranges, ovens and motors.
Test out all bridge lights and instruments that are on lighting circuits, and signal searchlights.

*Power Station*

Inspect all ventilating blowers, ice machines, machine shop motors, laundry motors, carpenter shop motors and flushing pump motors.
Clean, inspect and test searchlights.
Test all turret motors.
If under way, test steering motor and forced draft motors.

*I. C. and F. C. Station*

Insulation test on all circuits.
Inspect and clean gyro-compasses.
Inspect time-firing device.
Inspect ship's service telephone board.
Before battle stations or general quarters, test director firing, range and deflection instruments, turret bells and buzzers, and target turret transmitters.
Before getting under way, test all bridge instruments.
Test general alarm gongs and howlers.

*Dynamo Repair Station*

Inspect running plant and all sea valves.
Jack idle machinery.
Carry on repairs.

WEEKLY

*Dynamo Station*

Inspect all power division compartments.

Blow out generators in running plant with air.

Check up all watt meters.

Check up voltmeters on running generator panel.

Inspect circuit-breaker settings.

*Lighting and Shop Station*

Clean up work shop.

Inspect and test branch circuits in fire and engine rooms for low resistance.

Clean up storeroom A-24-S.

Check up lamp expenditures.

Check up G. S. K. chit book.

Inspect work books and work order briefs.

Test out fire and engine room auxiliary lights.

Inspect and check up portables.

*Power Station*

Inspect and test fresh-water pump motors, capstan motors, deck winch motor, forced draft motors, all turret motors and panels, steering motor, 5-inch hoist motors, ice-cream motor.

Make insulation test on all motors and turrets.

*I. C. and F. C. Station*

Discharge and charge gyro-batteries, I. C. batteries, telephone batteries and auxiliary lighting-circuit batteries.

Test general alarm contact makers.

Test all water-tight door warning-signal contact makers.

Clean plotting room and I. C. room, telephone repair shop.

*Dynamo Repair Station*

Test idle generators and auxiliaries under steam.

Test atmospheric valve, sentinel valve, back-pressure trip and overspeed trip.

MONTHLY

*Dynamo Station*

Insulation test of power and lighting circuits.

Insulation test of generators overall.

Inspection of circuit-breakers.

Renew oil in dynamo room exhaust blowers.

Inspect and clean thoroughly generators after monthly run.

*Lighting and Shop Station*

Inspect and check up tools and instruments.

Inspect and test lighting circuits and panels.

Inspect and clean out switches and panels of galley and bakeshop ranges, ovens and motors.

Inspect and test portable blowers.

Inspect stores and material in A-24-S.

*Power Station*

Make individual insulation test on each motor.

Water and charge all storage batteries.

Open and inspect all closed laundry motors.

*I.C. and F.C. Station*

Inspect and clean motor generators for telephone, telephone-ringing, I.C., gun-firing, and warning signal.

Inspect and clean all batteries.

Inspect helm-angle transmitter.

*Dynamo Repair Station*

Overhaul idle plant. Re-pack generator and auxiliary steam stops and generator throttles.

Examine water and oil service. Grind in and re-pack valves.

Examine, clean and adjust generator and auxiliary reducing valves.

Examine carbon packing on all turbines.

Re-pack lifting valves.

Filter oil in generator wells.

Blow out condenser, examine tubes and zincs.

Circulating engine: Take off water casing of pump, examine keys and set screws. Take off cylinder head, examine cylinder, piston and valve. Vaseline cylinder. Examine oil pump and bearings. Re-pack rod and stem.

Air pump: Take off cylinder head. Vaseline cylinder. Same for valve chest. Re-pack rods and stems. Take bull's eyes off on water end. Examine valves.

Hotwell pump: Take off cylinder head and valve-chest cover. Vaseline cylinders. Re-pack rod and stem. Examine valves in water end.

Traps: Take up on leaks. Grind in main and pilot valves. Re-pack cut-out valves.

Drain valves: Grind in and re-pack all reducing and pump drain valves, and steam and exhaust valves on all pumps.

Hotwell tank: Clean out and take up on leaks.

QUARTERLY

*Dynamo Station*

Make insulation tests on all circuits from dynamo and distribution rooms.
Make up log sheet data for quarterly returns.
Make insulation test on generators as follows: Armature to armature; drop across the separate fields; air-gap clearance; ground test over-all; insulation of feeders; armature fields and rheostat to ground.

*Lighting and Shop Station*

Check up quarterly report.
Inspect and repair all bracket fans.
Inventory tools and instruments.

*Power Station*

Lift portable searchlights off base and examine turntables, if these lights are kept on deck.

SEMI-ANNUALLY

*Dynamo Station*

Before target practice, shut power off distribution boards, tighten all studs and inspect for weak insulation and chafed leads.

*Dynamo Repair Station*

Grind in generator and auxiliary steam stops, sentinel, back-pressure, and carbon steam seal relief valves, atmospheric and trap cut-out valves.
Overhaul carbon steam seal reducing valves.
In dry dock: Grind in sea valves and renew zincs.
Take clearances on all generator rotors.
Examine thrusts.

ANNUALLY

*Power Station*

Lift mast searchlights off bases and examine turntables.

*I.C. and F.C. Station*

Make complete examination of all range and deflection circuits and tighten all connections.

Forms were printed aboard ship for reporting results of tests, current consumption, etc.

In addition to these forms, a book was kept with a list of circuit numbers on each page, against which was written each day the insulation resistance of the various circuits.

Monthly curves (Figs. 1 and 2) were also kept, showing the light, power and total consumption of electricity for each day

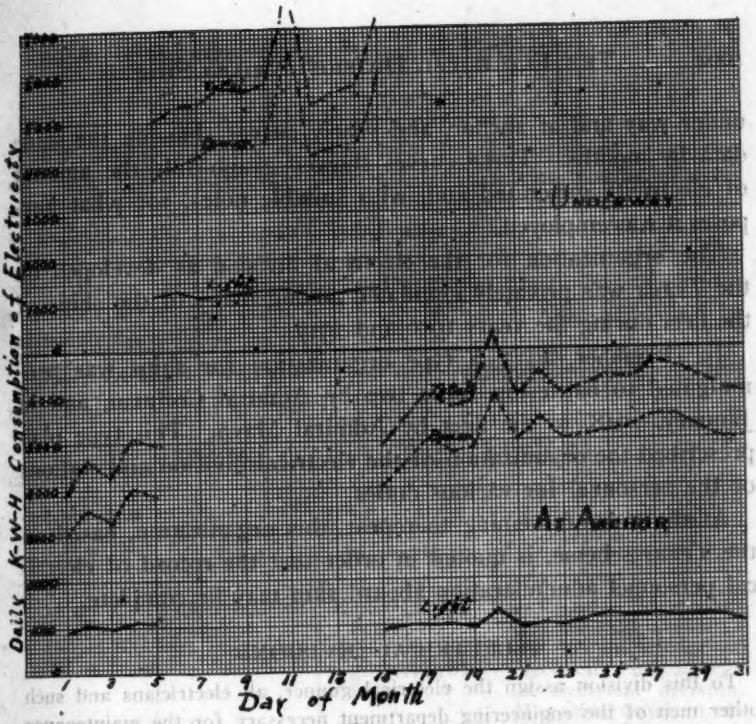

Daily K-W-H Consumption of Electricity
Day of Month

FIG. 1.

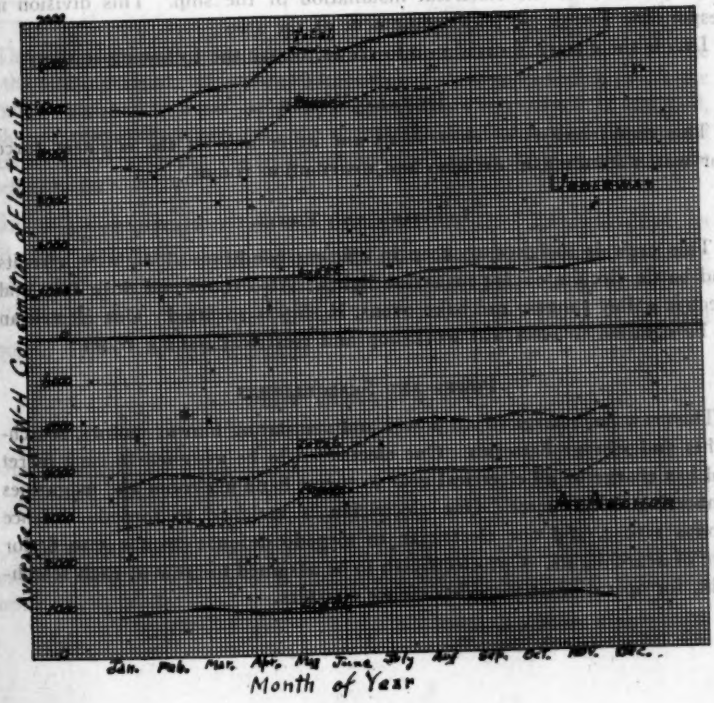

Average Daily K-W-H Consumption of Electricity
Month of Year

FIG. 2.

under way and at anchor, and yearly curves showing the same data by months. These curves showed graphically the amount of electricity generated and, with suitable notes, for what purposes it was employed.

The organization for the electrical division as developed on the *Texas* was privately circulated among many of the ships of the fleet during the years 1916 and 1917.

In December, 1917, a type organization for ships was promulgated to battleship force two by Admiral Coffman, and in January, 1918, to the fleet by Admiral Mayo. This type plan prescribed the organization of the electrical division and stations of the personnel for various duties.

At the risk of seeming to repeat, this organization, based on the *Texas* scheme, is quoted in order that the record of electrical personnel administration aboard ship may be complete.

## ELECTRICAL DIVISION

To this division assign the electrical gunner, all electricians and such other men of the engineering department necessary for the maintenance and operation of the electrical installation of the ship. This division is responsible for all electrical equipment of the ship.

Divide the electrical division into crews to man the following stations:

### DYNAMO WATCH

This crew consists of electricians and other men of the engineer force for watch standing in dynamo and distribution rooms.

### LIGHTING AND POWER

This crew is assigned to keep in efficient condition all lighting circuits and battle circuits except magazine lights. Also room and desk fans and electric galley ranges, and bake ovens, if ship is so fitted. One electrician to be detailed to electrical workshop and electrical issuing room.

### POWER AND SEARCHLIGHTS

The crew has charge of all power and ventilating blower motors, searchlights and storage batteries. One electrician to be assigned to each turret and has charge of all electrical gear in turret handling room and magazines connecting with turret. One electrician is assigned to torpedo defence groups 1 to 4, and one electrician to torpedo defence groups 5 to 8, for care of searchlights. One electrician to be assigned to crew of each searchlight, for operation at torpedo defence quarters.

INTERIOR COMMUNICATION AND FIRE CONTROL

This crew has the duty of testing and electrical repair of all interior communication circuits and instruments, ship's service telephones, gyro-compasses, fire-control telephones, and instruments and firing circuits up to the locks of the guns, and the range-finders.

Divide each station into four sections, for the purpose of standing watch, liberty, messing, berthing, etc.; as far as practicable, assign men to stations so that they will have the same station for battle that they have for maintenance.

Other extracts from the "type organization" applying to the electrical personnel are set forth below:

MANNING OF OFFICERS' STATIONS

| Order in which stations are to be manned | Stations | | Rank, station, watch, division, etc. |
|---|---|---|---|
| | Battle | Other than battle | |
| 37 | Electrical officer. Plotting room | Electrical officer. Assistant engineering officer. | Lieutenant, Lieutenant (j. g.) or ensign, selected for his knowledge of electricity, has charge of electrical division. May stand watch in engineering department. |

The electrical officer, if qualified for fire-control duties, shall be in charge of the plotting room. If the electrical officer is not so qualified, the above arrangement shall be used. If there is no regular electrical officer assigned, a plotting room officer performs the necessary electrical duties; the general doctrine being that the electrical officer shall have some station in the plotting room.

In this organization the maintenance of the dynamo engines and their auxiliaries are not under the electrical officer, but are under the auxiliaries division of the engineering department.

Stations of electrical personnel for ship-control, fire-control and general drills are given below:

SHIP CONTROL

CENTRAL STATION

One electrician for gyro-compasses.

INTERIOR COMMUNICATION ROOM

One electrician tends switchboard, looks out for motor generators and stands by to shift navigational instrument control from one station to another as required.

### FORWARD AND AFTER REPAIR STATIONS

Such electricians as may be required, depending on the construction of the ship.

### FORWARD DISTRIBUTION ROOM

Electrical gunner in charge tests out all communications, energizes all fire- and ship-control circuits. Stops blowers not required. Engine-room and fire-room blowers will not be stopped. Furnishes power and light to necesary circuits. Stands by to stop ventilation blowers in case powder gases are drawn in. Magazine exhaust blowers shall be kept running to withdraw other fumes. Sees fire-extinguishing apparatus and fresh water at hand. Receives reports from after dynamo room and distribution rooms, and forward dynamo room, and reports ready to starboard engine room. Stops ventilating supply blowers leading to magazines.

| PERSONNEL | DUTY |
|---|---|
| Electrical gunner | In charge. |
| Chief electrician | In charge, distribution switchboard. |
| One electrician | Switch operator and communications. |
| Three electricians | Repairs. |

### AFTER DISTRIBUTION ROOM

Electrician in direct charge. Tests out line of communications, stands by to handle circuits aft as directed from power forward. Reports to forward distribution room when ready. Stands by to stop ventilation blowers immediately in case powder gases are drawn in. Stops ventilating blowers leading to magazines.

| PERSONNEL | DUTY |
|---|---|
| One electrician | In charge. |
| One electrician | In charge of switchboard. |
| One electrician | Operates switches and communications. |
| Two electricians | Repairs. |

### FORWARD DYNAMO ROOM

Machinist's mate in direct charge. Starts all generators. Stands by to equalize, divide or shift load as may be required. Closes battle gratings and water-tight doors; sees chemical fire extinguishers in place and fresh water at hand. Reports to forward distribution room when ready.

| PERSONNEL | DUTY |
|---|---|
| One machinist's mate | In charge. |
| One electrician | On watch and generator switchboard. |
| One machinist's mate | On watch. |
| One oiler | On watch. |

### AFTER DYNAMO ROOM

Machinist's mate in charge. Starts all generators. Stands by to equalize, divide or shift load as may be required. Closes battle gratings and watertight doors; see chemical fire extinguishers in place and fresh water at hand. Reports to after distribution room when ready.

| PERSONNEL | DUTY |
|---|---|
| One machinist's mate | In charge. |
| One electrician | On watch and generator switchboard. |
| One machinist's mate | On watch. |
| One oiler | On watch. |
| STARBOARD ENGINE ROOM | One electrician, lighting. |
| MIDDLE ENGINE ROOM | One electrician, lighting. |
| PORT ENGINE ROOM | One electrician, lighting. |
| ENGINEER'S REPAIR STATION | Electricians, repairs. |

## FIRE CONTROL

### PLOTTING ROOM

| PERSONNEL | DUTY |
|---|---|
| Switchboard operator | Switchboards. |

*(*Usually chief electrician of fire-control crew.*)

### EACH TURRET

One electrician ..... Repairs to electrical installation.

### SEARCHLIGHTS

One electrician, each searchlight .... Operates light.

## TYPE BILL FOR ADMINISTRATIVE PURPOSES

Getting under way.

Coming to anchor.

Mooring and unmooring.

Electrical gunner ..... At electric windlass.

### COALING BILL

Electrical division ..... Runs winches. Repairs defects. Excess men to coal.

### FIRE BILL

FIRE OTHER THAN IN ACTION

Electrical gunner ..... Starts generators for power on winches. Sends party to location of fire to stop blowers, pull fuses, etc.

---

*Italics are mine.

DIVISIONAL DUTIES

| | |
|---|---|
| Stops blowers | Electrical division, only in part of the ship where fire is located. Stands by to start if needed. Stops all magazine supply blowers. |
| Electrical repairs | Electrical. To pull fuses; in case of electrical fires supply portable lights and blowers. |

COLLISION BILL

COLLISION OTHER THAN IN ACTION

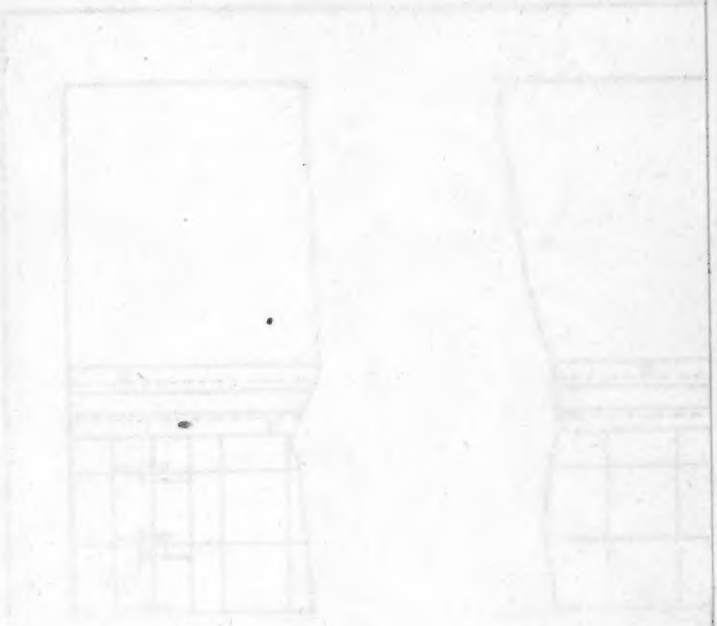
| | |
|---|---|
| Electrical gunner | Starts generators for power for cranes, winches and anchor gear winches. |

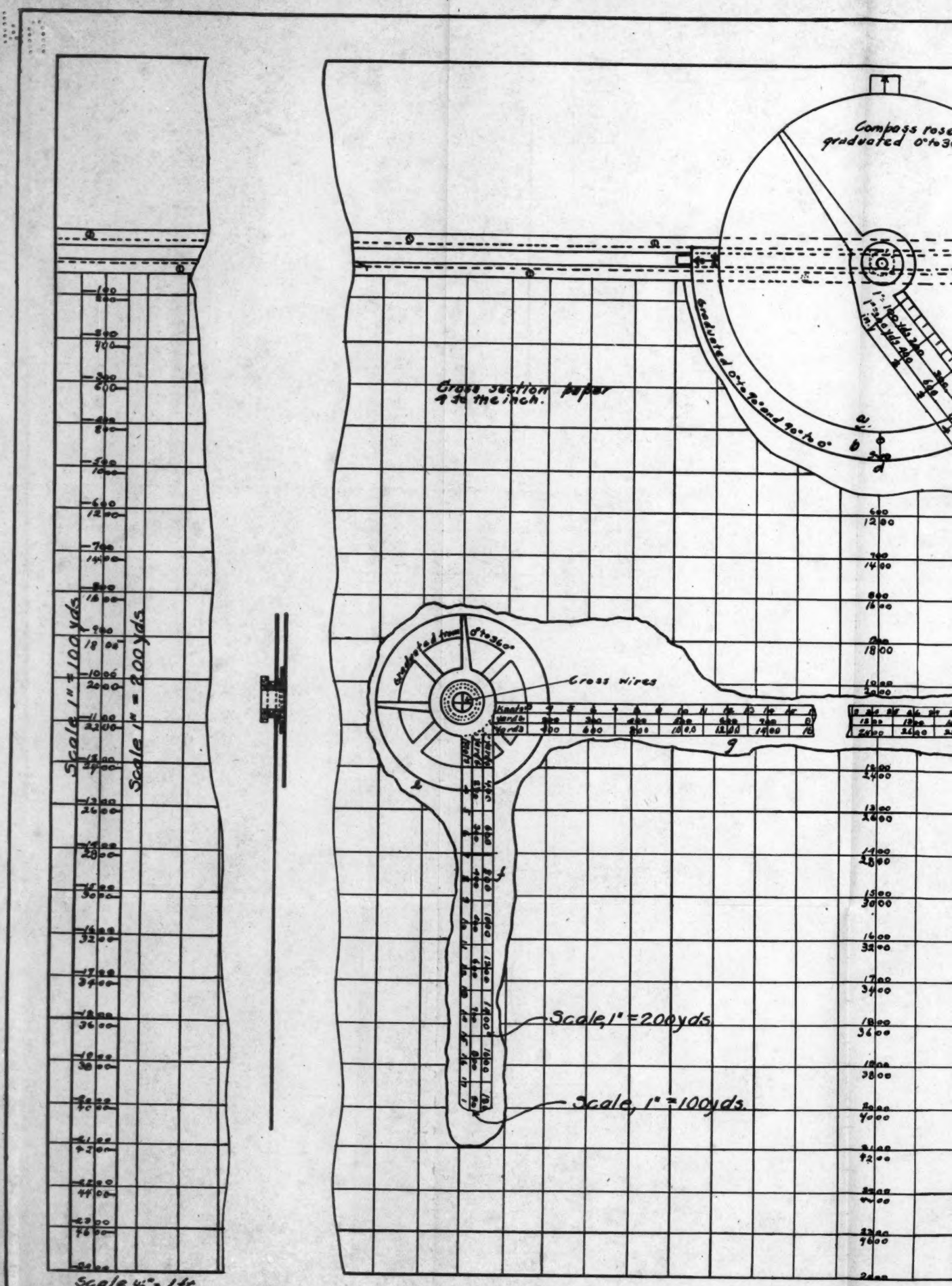
The above organization is in effect to-day for battleships of the Atlantic fleet.

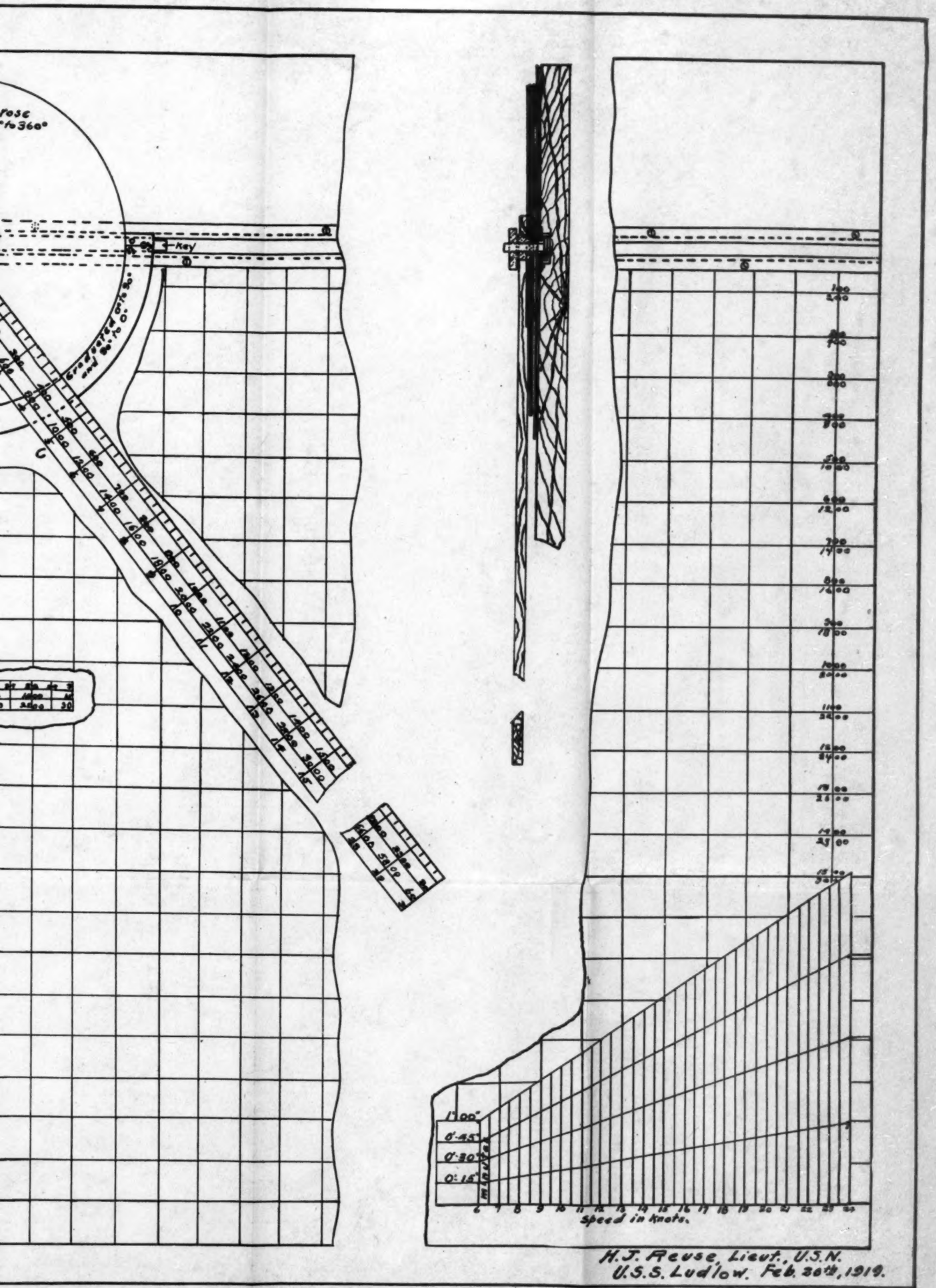
Soon after the outbreak of war, 100 men with electrical training were obtained and given commissions as lieutenants, junior grade. After a course at the Naval Academy, they were sent to sea for three months, most of them to battleships, two to a ship. At the end of that time, one was retained aboard for electrical duty, and the other made available for shore duty at navy yards and in the Bureau of Steam Engineering.

The experience of these officers in civilian life, together with their naval training, makes them a valuable asset, and it is hoped that those who have proved their value and aptitude for the service may be retained in the navy.

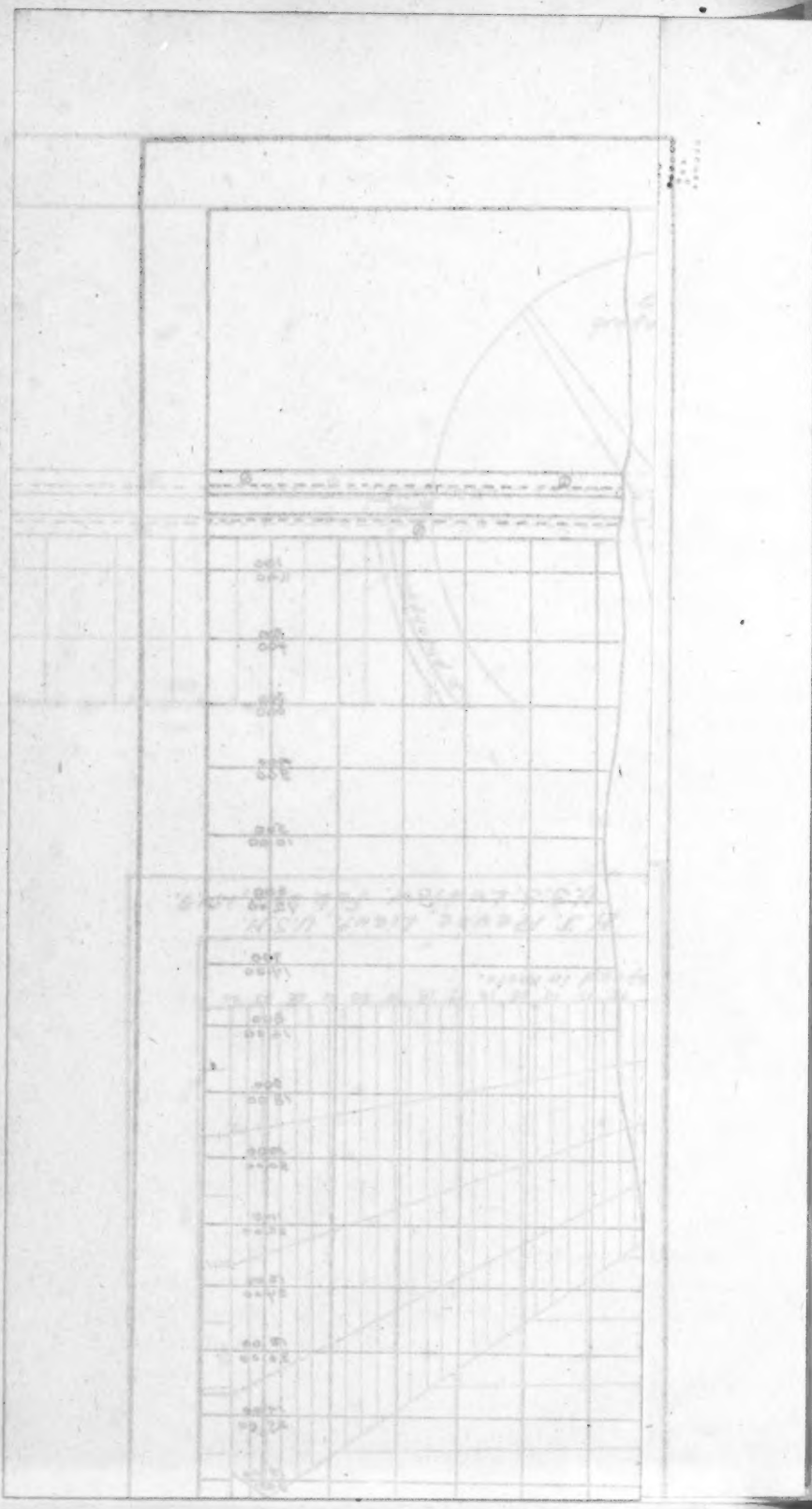
The electrical plants of our battleships are in efficient condition to-day, and every effort must be made to keep them so. Their increased efficiency is due in a large measure, it is believed, to the assignment of electrical officers to our ships and the placing of all electrical personnel and material under their supervision.




Compass rose graduated 0° to 360°
graduated 0° to 90° and 90° to 0°
Cross section paper 4 to the inch.
graduated from 0° to 360°
Cross Wires
Scale, 1" = 200 yds.
Scale, 1" = 100 yds.
Scale 1" = 100 yds.
Scale 1" = 200 yds.
Scale 4½" = 1 ft.




H.J. Reuse, Lieut., U.S.N.
U.S.S. Ludlow. Feb. 20th, 1919.



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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

# IMPROVED MANEUVERING AND MOORING BOARD

Designed by LIEUTENANT H. J. REUSE, U. S. Navy.

The maneuvering and mooring board described below will be found useful in making approaches at target practice, changing position in formation and working out mooring problems. It is believed that most maneuvering and mooring problems can be worked out in much less time and with less labor than when using the regulation mooring board.

The board consists of a movable compass rose *a*, graduated from 0° to 360°, so arranged as to move about the center and along the edge of the board. The compass rose can be clamped in any convenient position at the top of the board, its position depending on the conditions of the problem.

Under the compass rose *a* is another rose *b*, graduated on either side of *d* from 0° to 90° and from 90° to 0°. *b* is arranged to move along the board with *a*, but does not turn about the center, a key preventing the movement. Pivoting about the center of both compass roses is an arm *c*, graduated in yards to the same scale as the plotting sheet. Any number of scales can be used on the same arm. In this case ¾ inch equals 100 yards and 200 yards, respectively. The arm is also graduated in inches from zero to 30 inches. A pointer is attached to the arm, so that either the direct or reverse bearing can be read off the compass rose.

The protractor *e* consists of a compass rose having two arms, *f* and *g*, pivoting about the center. The arm *f* can be clamped on any course or bearing desired, while *g* is free to move about the center of the rose. Both have pointers, so that either the direct or reverse bearing can be read. Both arms are gradu-

ated in yards to the same scale as the arm *c*, and are also graduated in knots. In this case, one-half inch equals 1 knot, although any arbitrary scale may be used provided both arms are graduated the same. A pair of cross wires locates the center of the compass rose.

The plotting sheet, mounted on the board, is of cross-section paper, four squares to the inch. In this case one side of a square equals 25 yards or 50 yards, depending on the scale used. Every fourth line is drawn in red ink to facilitate plotting.

The diagram near the lower right-hand corner will be found useful in determining the time required to perform the evolution and will be explained in connection with examples of problems given below.

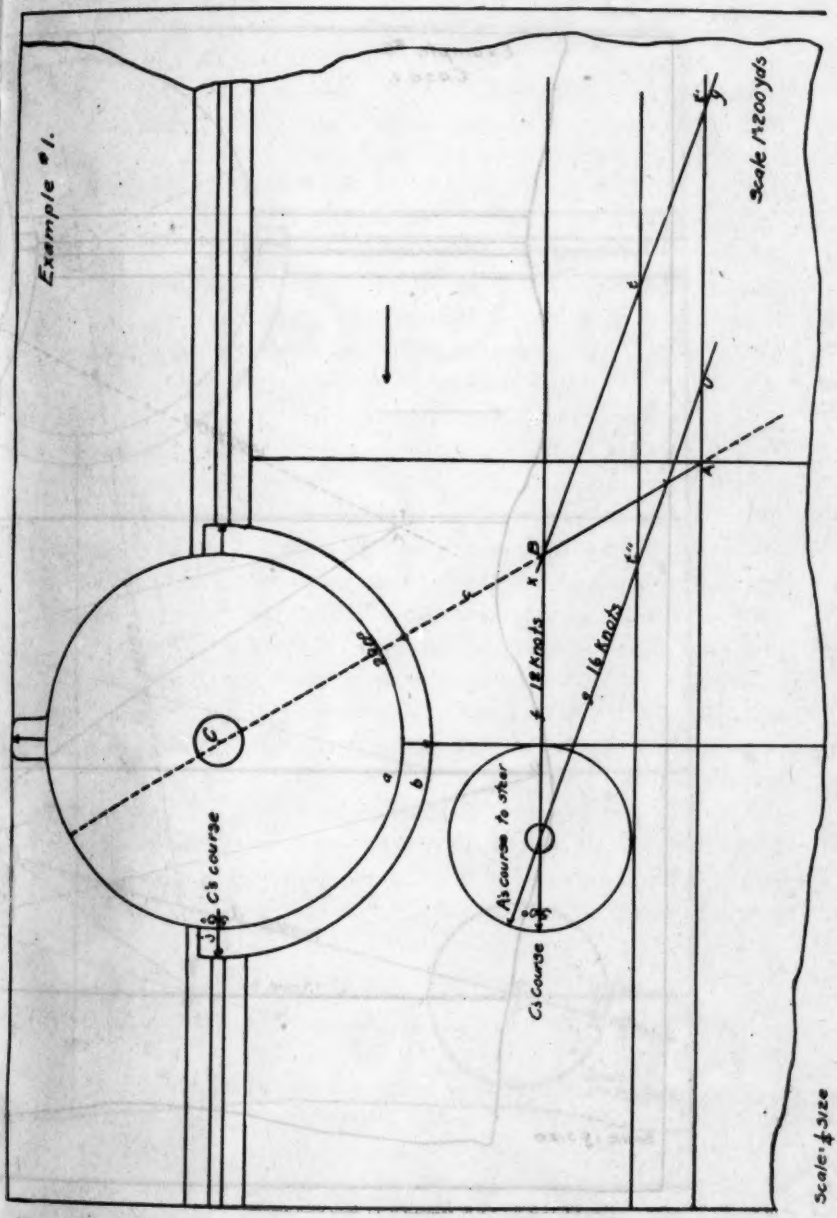
In the sketches of problems, the cross-section is not drawn. The black horizontal and vertical lines shown are those nearest the plotted positions on the plotting sheet. The full lines in red ink are the only lines required to be drawn in working out the problems. In some cases it is not necessary to draw any lines, as shown in Examples 3 and 5. In Example 5 the turning circle need not be plotted.

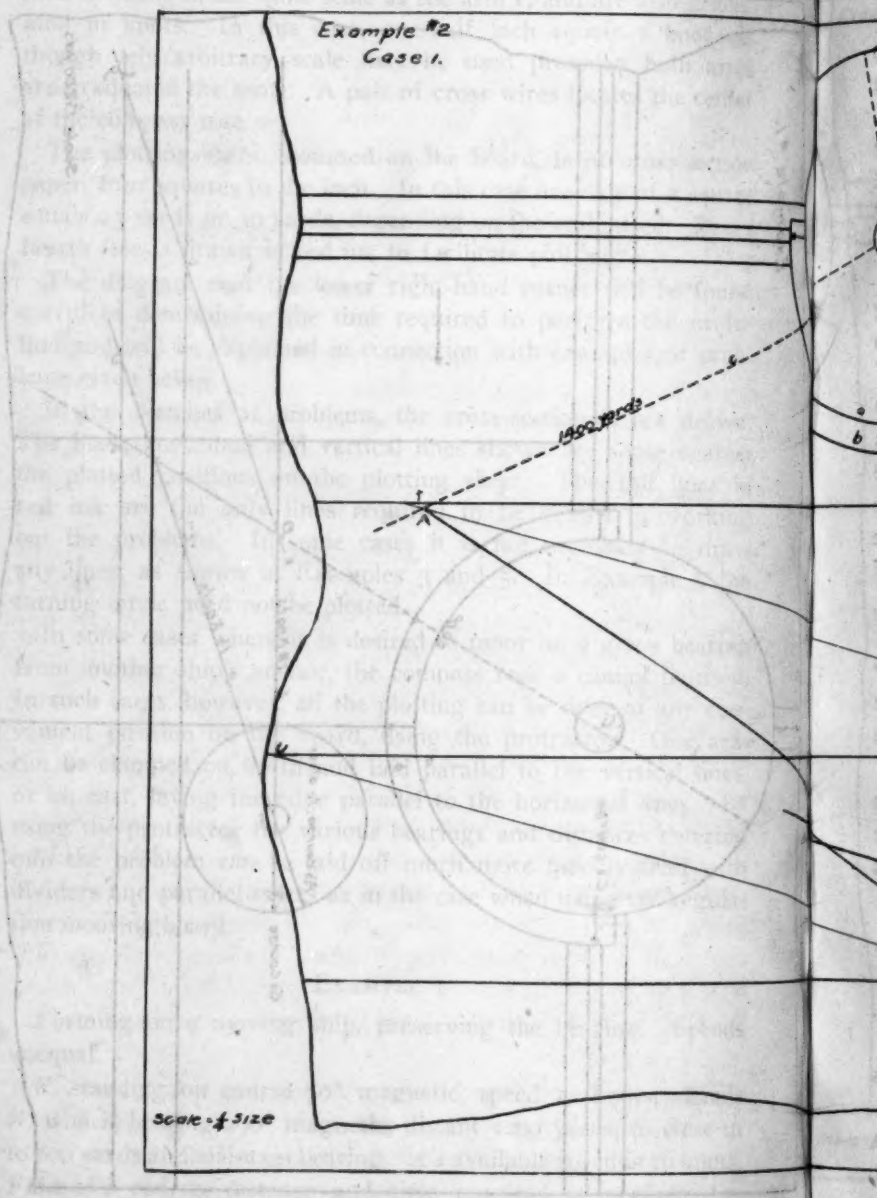
In some cases where it is desired to moor on a given bearing from another ship's anchor, the compass rose *a* cannot be used. In such cases, however, all the plotting can be done at any convenient position on the board, using the protractor. One arm can be clamped on north and laid parallel to the vertical lines, or on east, laying the edge parallel to the horizontal lines. By using the protractor the various bearings and distances entering into the problem can be laid off much more quickly than with dividers and parallel rulers as in the case when using the regulation mooring board.

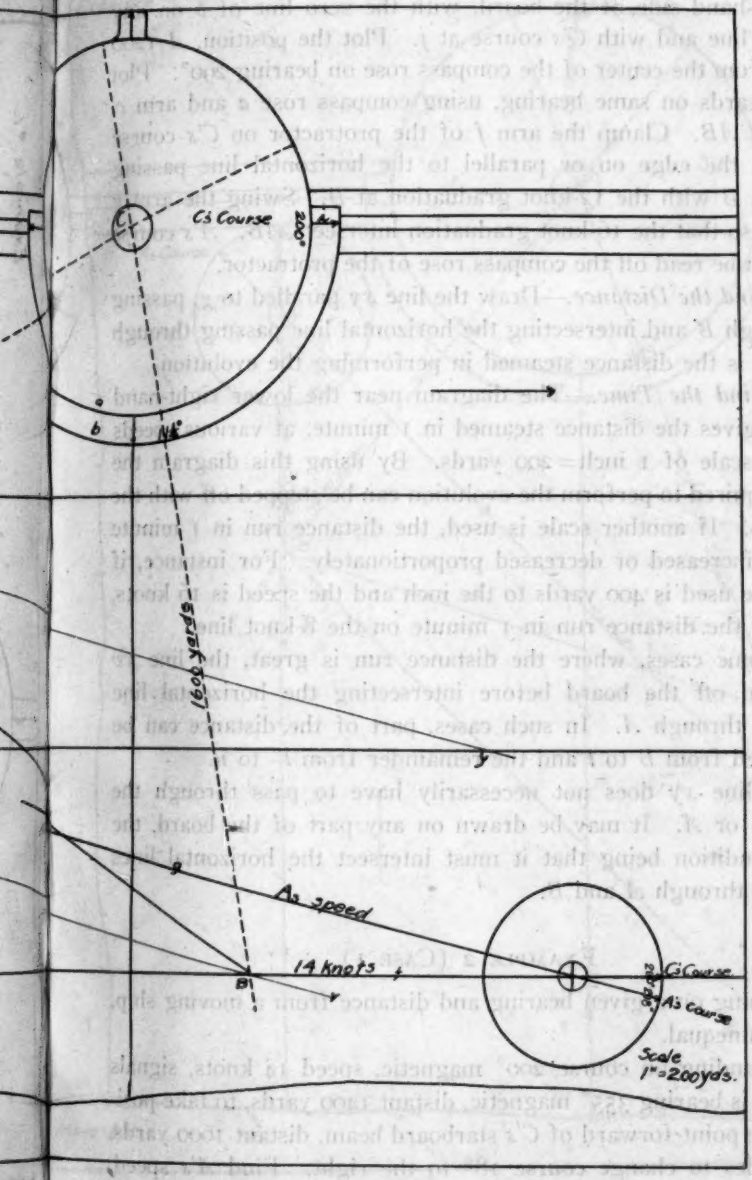
EXAMPLE 1

Forming on a moving ship, preserving the bearing. Speeds unequal.

*C*, standing on course 50° magnetic, speed 12 knots, signals *A*, who is bearing 290° magnetic, distant 1200 yards, to close in to 800 yards and maintain bearing. *A's* available speed is 16 knots. Find *A's* course, distance and time required to perform the evolution.


Example #1.
Scale 1/200 yds
18 Knots
16 Knots
A's course to steer
C's Course
C's course
Scale: 1/32 in


Example #2
Case 1.
Scale - ½ size


Cs Course
200'
b
N
1600 yards
As speed
14 Knots
B
Cs Course
As Course
Scale
1"=200yds.

*To Find the Course.*—Clamp the compass roses *a* and *b* near the left-hand side of the board, with the zero line of *b* on any vertical line and with *C's* course at *j*. Plot the position, *A* 1200 yards from the center of the compass rose on bearing 290°. Plot *B* 800 yards on same bearing, using compass rose *a* and arm *c*. Connect *AB*. Clamp the arm *f* of the protractor on *C's* course and lay the edge on or parallel to the horizontal line passing through *B* with the 12-knot graduation at *B*. Swing the arm *g* around so that the 16-knot graduation intersects *AB*. *A's* course can then be read off the compass rose of the protractor.

*To Find the Distance.*—Draw the line *xy* paralled to *g*, passing it through *B* and intersecting the horizontal line passing through *A*. *Bt'* is the distance steamed in performing the evolution.

*To Find the Time.*—The diagram near the lower right-hand corner gives the distance steamed in 1 minute, at various speeds on the scale of 1 inch=200 yards. By using this diagram the time required to perform the evolution can be stepped off with the dividers. If another scale is used, the distance run in 1 minute can be increased or decreased proportionately. For instance, if the scale used is 400 yards to the inch and the speed is 16 knots, step off the distance run in 1 minute on the 8-knot line.

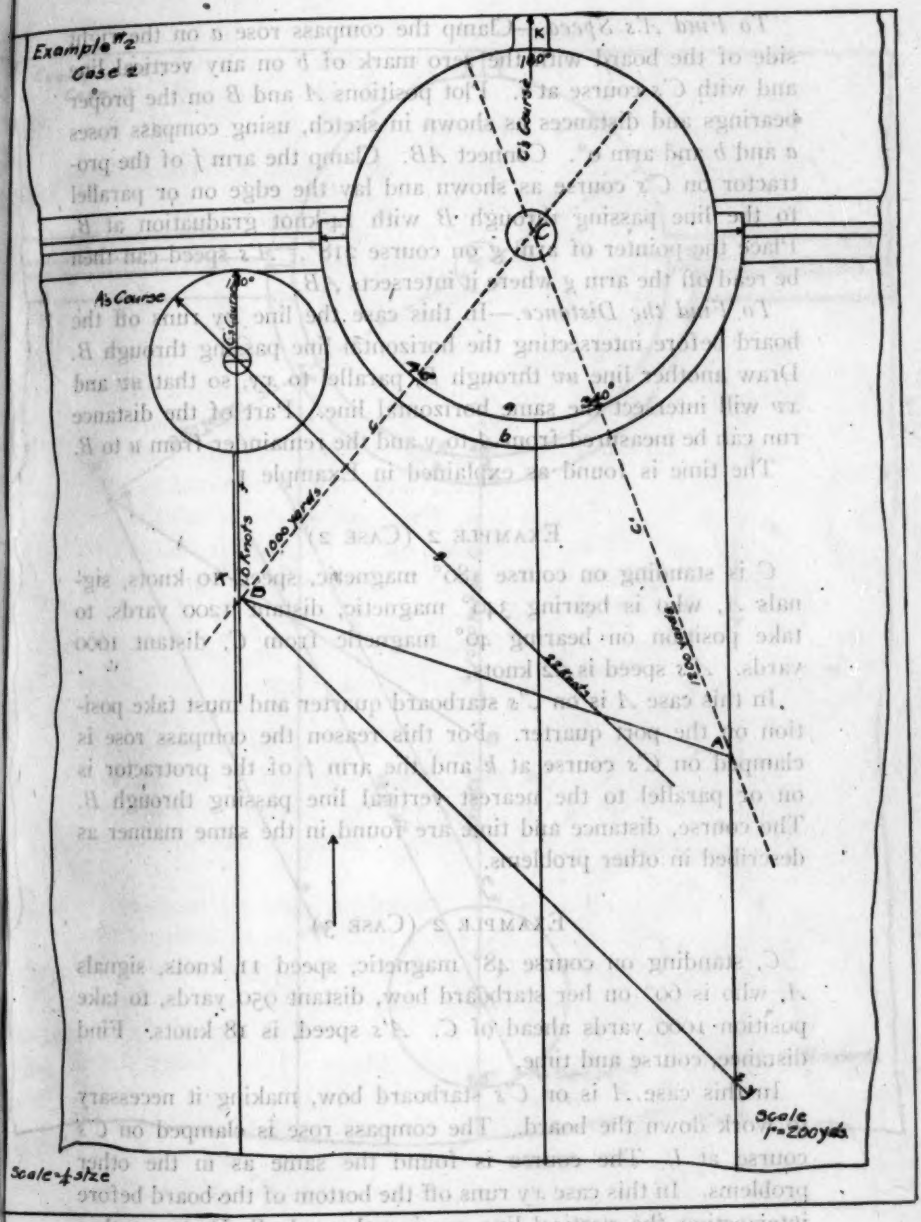
In some cases, where the distance run is great, the line *xv* will run off the board before intersecting the horizontal line passing through *A*. In such cases, part of the distance can be measured from *B* to *t* and the remainder from *t''* to *u*.

The line *xy* does not necessarily have to pass through the point *B* or *A*. It may be drawn on any part of the board, the only condition being that it must intersect the horizontal lines passing through *A* and *B*.

### EXAMPLE 2 (CASE 1)

Forming on a given bearing and distance from a moving ship, speeds unequal.

*C*, standing on course 200° magnetic, speed 14 knots, signals *A*, who is bearing 355° magnetic, distant 1400 yards, to take position one point forward of *C's* starboard beam, distant 1600 yards. *A* decides to change course 18° to the right. Find *A's* speed, distance run and time required to perform the evolution.


Example No 2
Case 2
K
100°
C's Course
A's Course
100°
C's Course
340°
340°
c
b
a
A
B
C
10 Knots
1000 Yards
11 Knots
C's Course
Scale
1=200yds
Scale-4 size

*To Find A's Speed.*—Clamp the compass rose *a* on the right side of the board with the zero mark of *b* on any vertical line and with *C's* course at *i*. Plot positions *A* and *B* on the proper bearings and distances as shown in sketch, using compass roses *a* and *b* and arm 0°. Connect *AB*. Clamp the arm *f* of the protractor on *C's* course as shown and lay the edge on or parallel to the line passing through *B* with 14-knot graduation at *B*. Place the pointer of arm *g* on course 218°. *A's* speed can then be read off the arm *g* where it intersects *AB*.

*To Find the Distance.*—In this case the line *xy* runs off the board before intersecting the horizontal line passing through *B*. Draw another line *uv* through *B*, parallel to *xy*, so that *uv* and *xv* will intersect the same horizontal line. Part of the distance run can be measured from *A* to *y* and the remainder from *u* to *B*.

The time is found as explained in Example 1.

### EXAMPLE 2 (CASE 2)

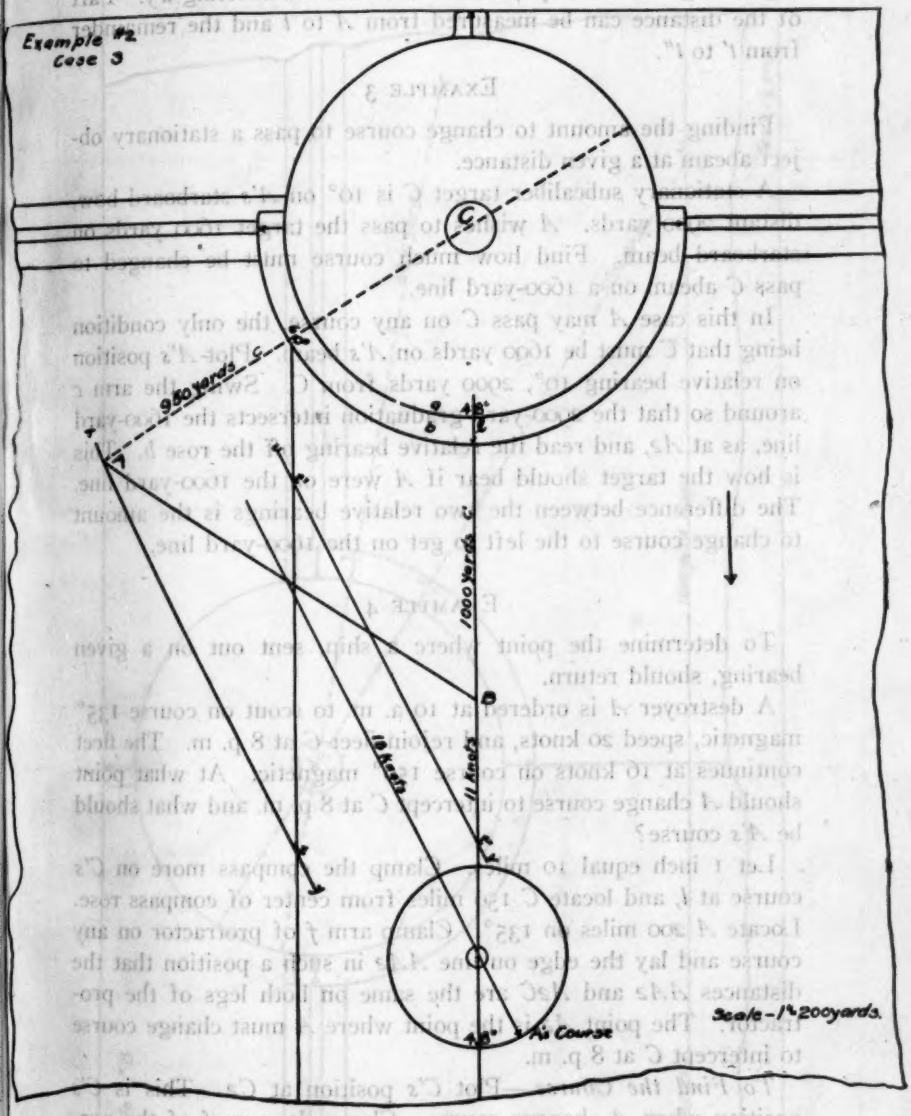
*C* is standing on course 180° magnetic, speed 10 knots, signals *A*, who is bearing 340° magnetic, distant 1200 yards, to take position on bearing 40° magnetic from *C*, distant 1000 yards. *A's* speed is 22 knots.

In this case *A* is on *C's* starboard quarter and must take position on the port quarter. For this reason the compass rose is clamped on *C's* course at *k* and the arm *f* of the protractor is on or parallel to the nearest vertical line passing through *B*. The course, distance and time are found in the same manner as described in other problems.

### EXAMPLE 2 (CASE 3)

*C*, standing on course 48° magnetic, speed 11 knots, signals *A*, who is 60° on her starboard bow, distant 950 yards, to take position 1000 yards ahead of *C*. *A's* speed, is 18 knots. Find distance, course and time.

In this case *A* is on *C's* starboard bow, making it necessary to work down the board. The compass rose is clamped on *C's* course at *l*. The course is found the same as in the other problems. In this case *xy* runs off the bottom of the board before intersecting the *vertical* line passing through *B*. Draw another line, *uv*, parallel to *xy* so that it intersects the vertical line pass-


Example #2
Case 3
C
950 yards
1000 Yards
11 Knots
Scale - 1" = 200 yards.

ing through *B* and any other *vertical* line intersecting *xy*. Part of the distance can be measured from *A* to *t* and the remainder from *t'* to *t''*.

### EXAMPLE 3

Finding the amount to change course to pass a stationary object abeam at a given distance.

A stationary subcaliber target *C* is 10° on *A's* starboard bow, distant 2900 yards. *A* wishes to pass the target 1600 yards on starboard beam. Find how much course must be changed to pass *C* abeam on a 1600-yard line.

In this case *A* may pass *C* on any course, the only condition being that *C* must be 1600 yards on *A's* beam. Plot *A's* position on relative bearing 10°, 2900 yards from C. Swing the arm *c* around so that the 2900-yard graduation intersects the 1600-yard line, as at *A2*, and read the relative bearing off the rose *b*. This is how the target should bear if *A* were on the 1600-yard line. The difference between the two relative bearings is the amount to change course to the left to get on the 1600-yard line.

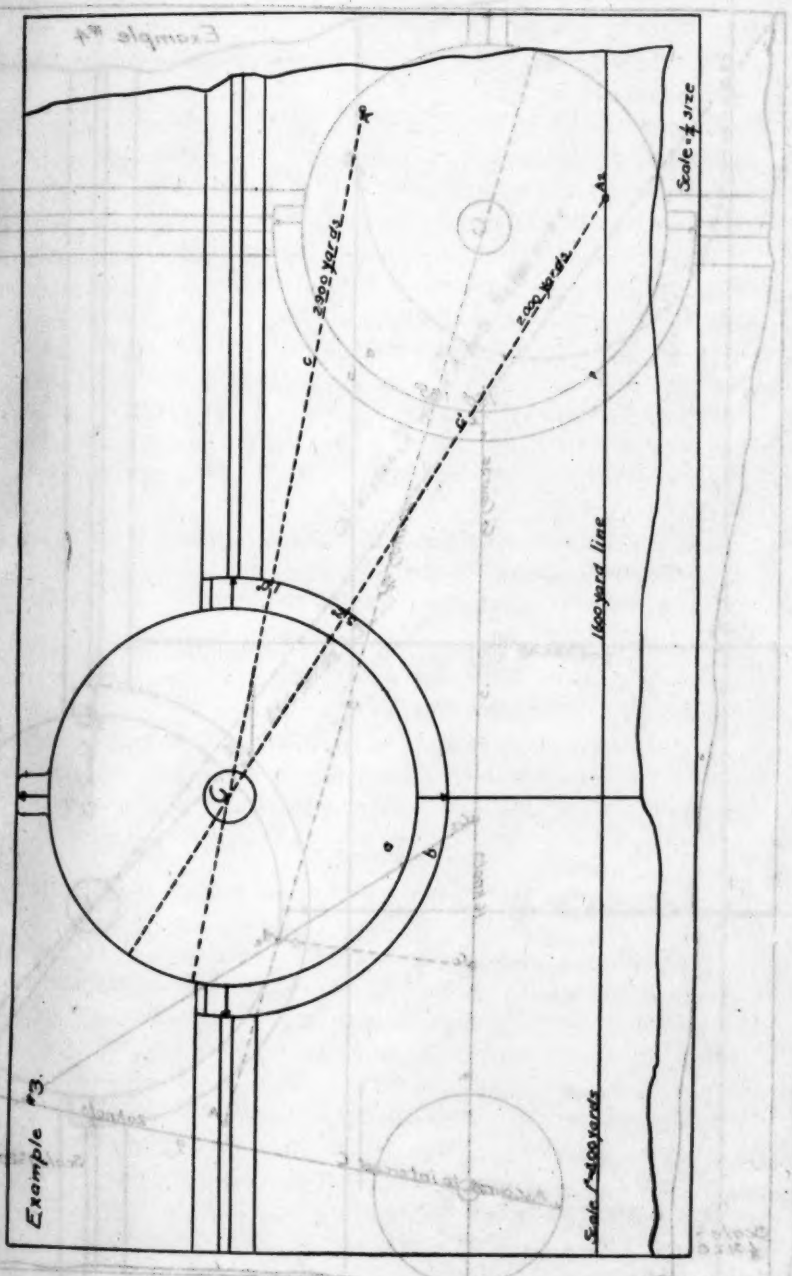
### EXAMPLE 4

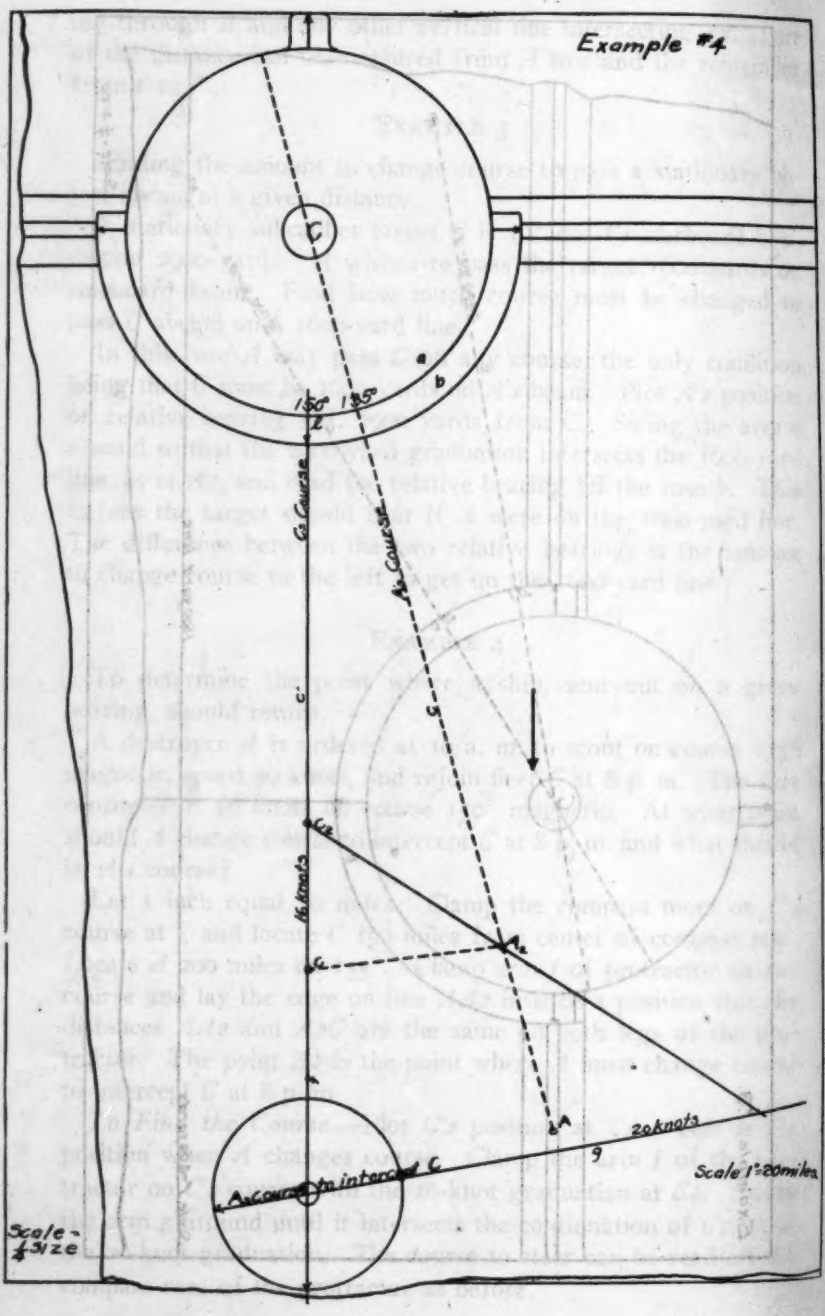
To determine the point where a ship, sent out on a given bearing, should return.

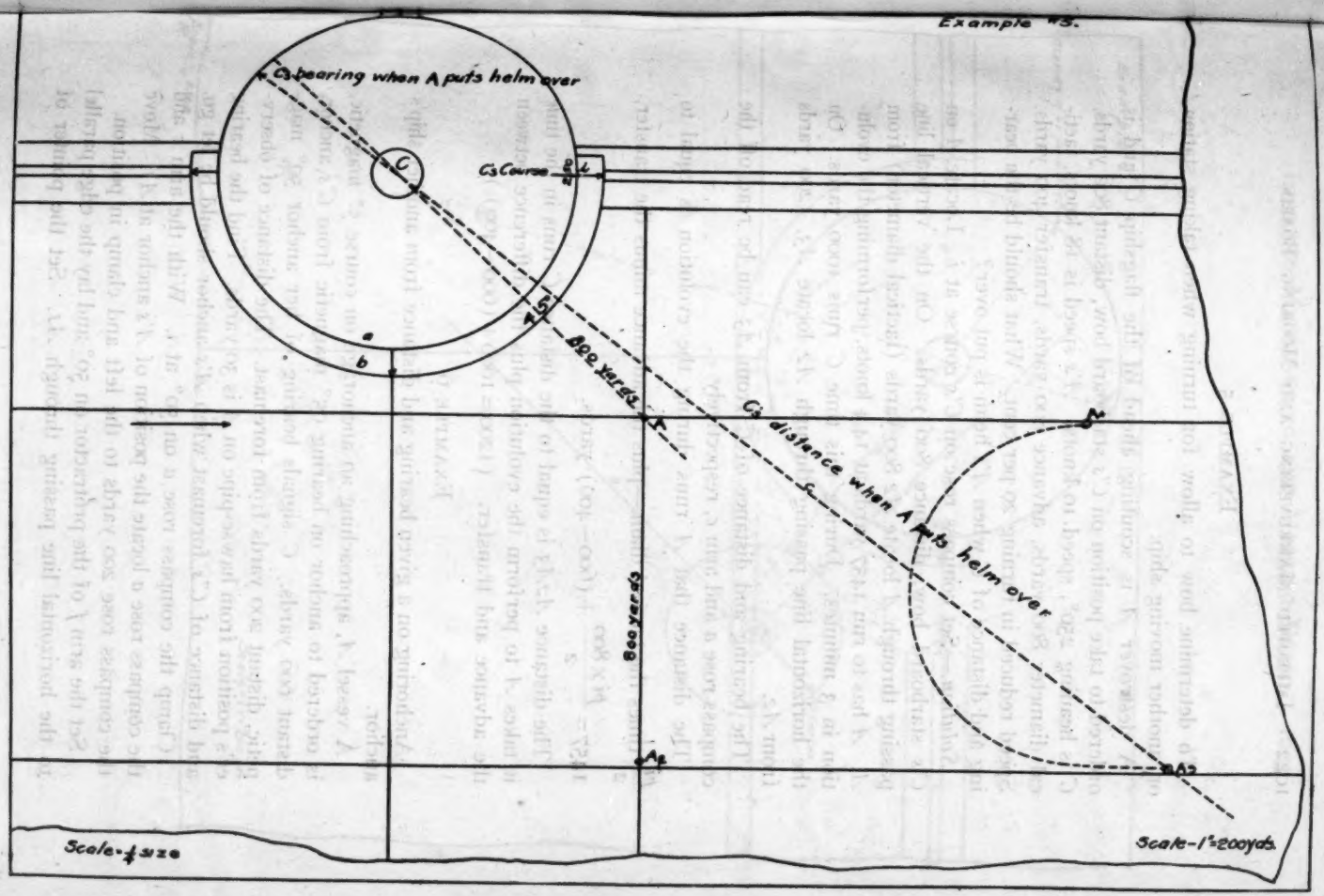
A destroyer *A* is ordered at 10 a. m. to scout on course 135° magnetic, speed 20 knots, and rejoin fleet *C* at 8 p. m. The fleet continues at 16 knots on course 150° magnetic. At what point should *A* change course to intercept *C* at 8 p. m. and what should be *A's* course?

Let 1 inch equal 10 miles. Clamp the compass more on *C's* course at *l*, and locate *C* 150 miles from center of compass rose. Locate *A* 200 miles on 135°. Clamp arm *f* of protractor on any course and lay the edge on line *AA2* in such a position that the distances *AA2* and *A2C* are the same on both legs of the protractor. The point *A2* is the point where *A* must change course to intercept *C* at 8 p. m.

*To Find the Course.*—Plot *C's* position at *C2*. This is *C's* position when *A* changes course. Clamp the arm *f* of the protractor on *C's* course with the 16-knot graduation at *C2*. Swing the arm *g* around until it intersects the continuation of *C2A2*, at the 20-knot graduation. The course to steer can be read off the compass rose of the protractor as before.


Example #3.
1800 yard line
Scale: 1/2 size


Example #4
Example #3.
135°
135°
C₂ Course
A₂ Course
16 knots
20 knots
9
Scale 1"=20 miles
A course to intercept C
Scale - Full size


Example #3.
C3 bearing when A puts helm over
C
C3 Course
a
b
800 yards
C3 distance when A puts helm over
c
800 yards
A1
A2
A3
Scale-1/2 size
Scale-1"=200yds

### EXAMPLE 5

To determine how to allow for turning when taking station on another moving ship.

A destroyer *A* is scouting ahead of the flagship *C* and is ordered to take position on *C's* starboard bow, distant 800 yards. *C* is heading 250°, speed 10 knots. *A's* speed is 18 knots, tactical diameter 800 yards, advance 800 yards, transfer 400 yards. Speed reduced in turning 20 per cent. What should be the bearing and distance of *C* when *A's* helm is put over?

*Solution.*—Set compass rose on *C's* course at *i*. Locate *A* on *C's* starboard bow, distance 800 yards. On the vertical line passing through *A* locate *A2* 800 yards (tactical diameter) from *A*. *A* has to run 1457 yards at 14.4 knots, performing the evolution in 3 minutes. During this time *C* runs 1000 yards. On the horizontal line passing through *A2* locate *A3*, 1200 yards from *A2*.

The bearing and distance of *C* from *A3* can be read off the compass rose *a* and arm *c*, respectively.

The distance that *A* runs during the evolution is equal to $\frac{pi}{2}$ times the tactical diam.—plus the advance minus the transfer,

$$1457 = \frac{pi \times 800}{2} + (600 - 400) \text{ yards.}$$

The distance *A2A3* is equal to the distance *C* runs in the time it takes *A* to perform the evolution plus the difference between the advance and transfer. (1200 = 1000 + (600 − 400).)

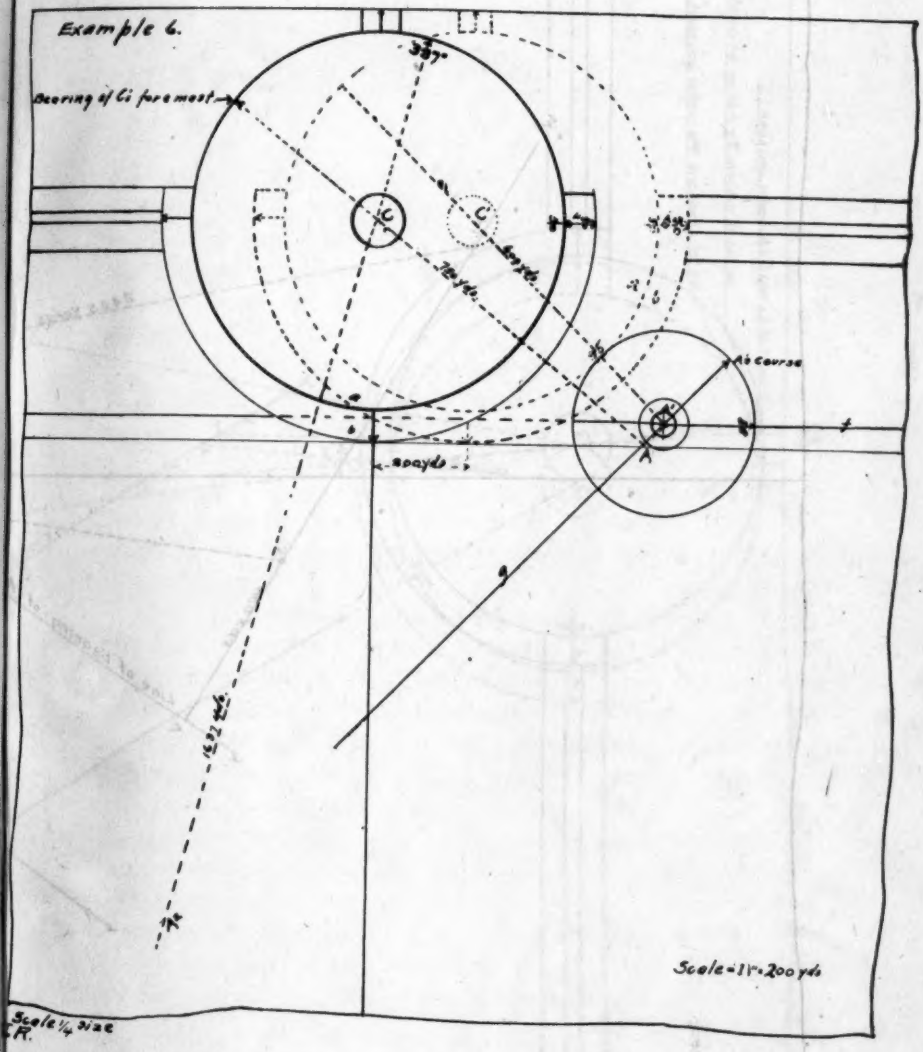
### EXAMPLE 6

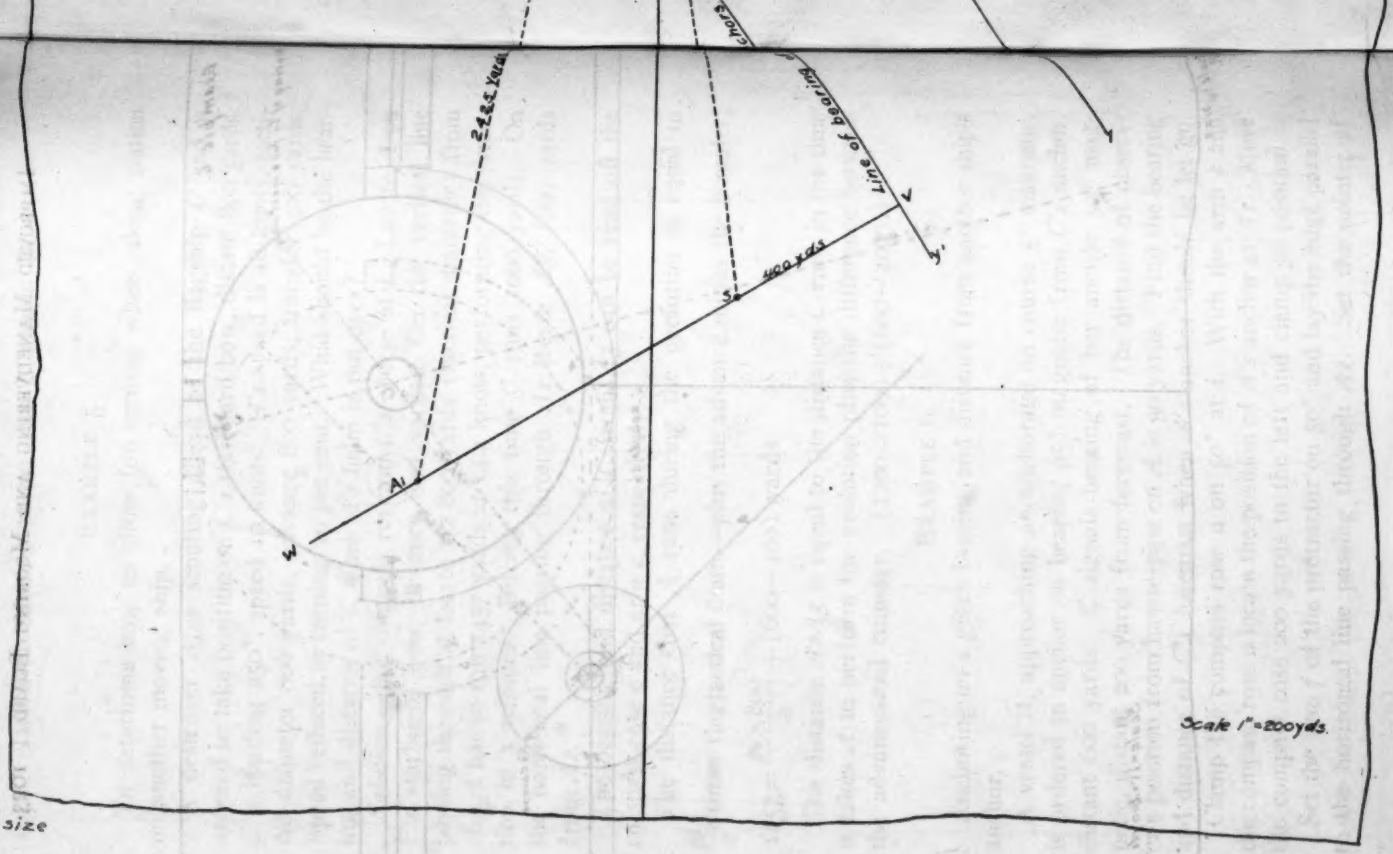
Anchoring on a given bearing and distance from another ship's anchor.

A vessel *A*, approaching an anchorage on course 5° magnetic, is ordered to anchor on bearing 95° magnetic from *C's* anchor, distant 600 yards. *C* signals bearing of her anchor 50° magnetic, distant 200 yards from foremast. The distance of observer's position from hawse-pipe on *A* is 30 yards. Find the bearing and distance of *C's* foremast when *A's* anchor should be let go.

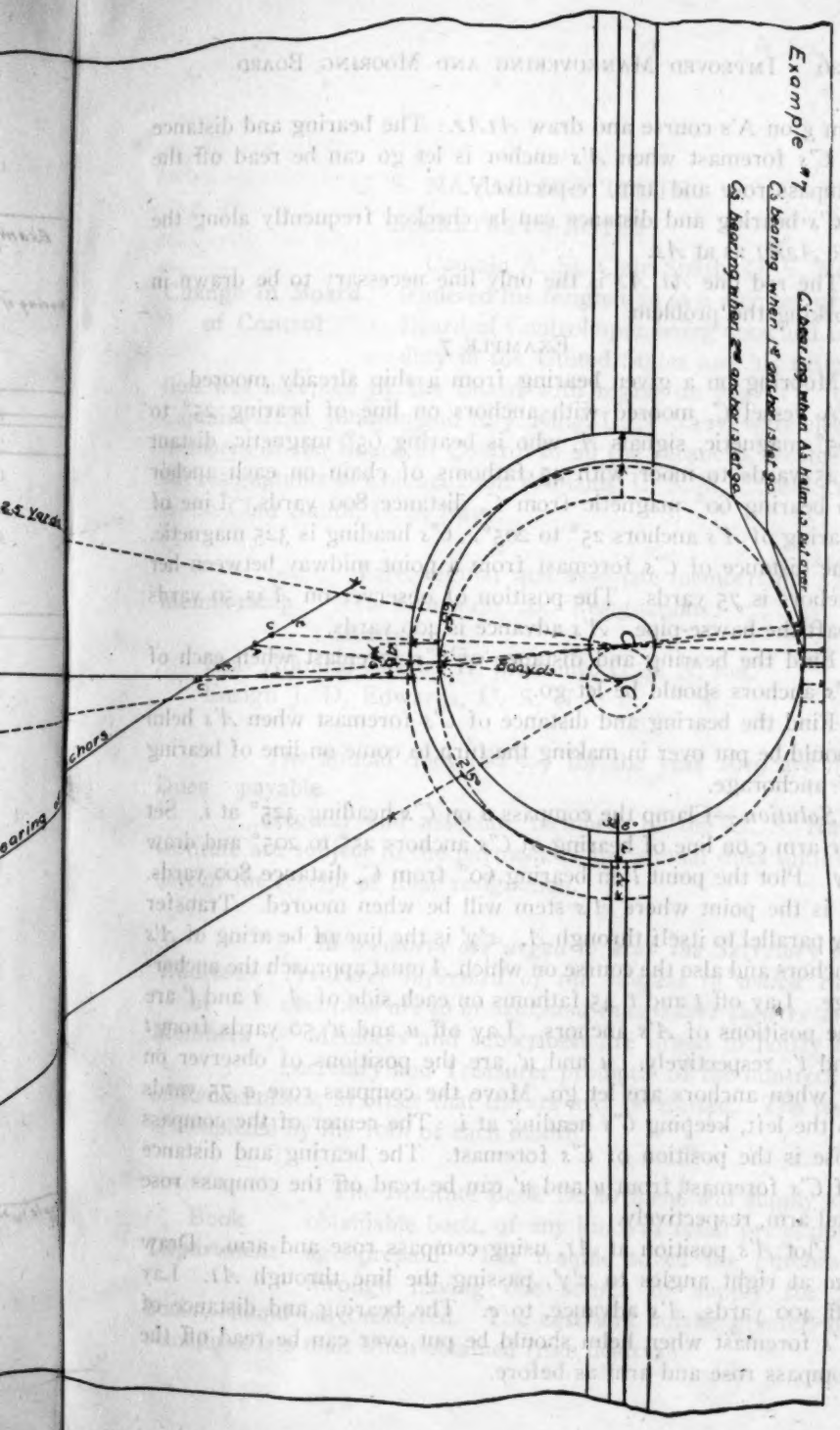
Clamp the compass rose *a* on 50° at *i*. With the arm *c* and the compass rose *a* locate the position of *A's* anchor at *A1*. Move the compass rose 200 yards to the left and clamp in position.

Set the arm *f* of the protractor on 50° and lay the edge parallel to the horizontal line passing through *A1*. Set the pointer of


Example 6.
Bearing of Ci foremost
387°
C
C
Course
Scale = 1" = 200 yds
Scale 1/4 size
R.




Scale ¼ size


Example #7
C's bearing when A's buoy is let go
C's bearing when 1st anchor is let go
C's bearing when 2nd anchor is let go
Buoys
C
A
B
c
c'
c''
25°
215°
360°
25 Yards

arm *g* on A's course and draw *A1A2*. The bearing and distance of *C's* foremast when *A's* anchor is let go can be read off the compass rose and arm, respectively.

*C's* bearing and distance can be checked frequently along the line *A2A1* as at *A2*.

The red line *A1 A2* is the only line necessary to be drawn in working the problem.

### EXAMPLE 7

Mooring on a given bearing from a ship already moored.

A vessel *C*, moored with anchors on line of bearing 25° to 205° magnetic, signals *A*, who is bearing 65° magnetic, distant 2425 yards to moor with 45 fathoms of chain on each anchor on bearing 60° magnetic from *C*, distance 800 yards. Line of bearing of *A's* anchors 25° to 205°. *C's* heading is 325 magnetic. The distance of *C's* foremast from a point midway between her anchors is 75 yards. The position of observer on *A* is 50 yards abaft the hawse-pipe. *A's* advance is 400 yards.

Find the bearing and distance of *C's* foremast when each of *A's* anchors should be let go.

Find the bearing and distance of *C's* foremast when *A's* helm should be put over in making the turn to come on line of bearing of anchorage.

*Solution.*—Clamp the compass *a* on *C's* heading 325° at *i*. Set the arm *c* on line of bearing of *C's* anchors 25° to 205° and draw *xy*. Plot the point *l* on bearing 60° from *C*, distance 800 yards. *A* is the point where *A's* stem will be when moored. Transfer *xy* parallel to itself through *A*. *x'y'* is the line of be aring of *A's* anchors and also the course on which *A* must approach the anchorage. Lay off *t* and *t'* 45 fathoms on each side of *A*. *t* and *t'* are the positions of *A's* anchors. Lay off *u* and *u'* 50 yards from *t* and *t'*, respectively. *u* and *u'* are the positions of observer on *A* when anchors are let go. Move the compass rose *a* 75 yards to the left, keeping *C's* heading at *i*. The center of the compass rose is the position of *C's* foremast. The bearing and distance of *C's* foremast from *u* and *u'* can be read off the compass rose and arm, respectively.

Plot *A's* position at *A1*, using compass rose and arm. Draw *vw* at right angles to *x'y'*, passing the line through *A1*. Lay off 400 yards, *A's* advance, to *e*. The bearing and distance of *C's* foremast when helm should be put over can be read off the compass rose and arm as before.

# U. S. NAVAL INSTITUTE

## SECRETARY'S NOTES

**Change in Board of Control**

Captain A. St. Clair Smith, U. S. Navy, tendered his resignation as a member of the Board of Control upon being detached from duty in the United States and his resignation was accepted by the Board with regret on May 13, 1919. Captains T. L. Johnson and E. J. King, U. S. Navy, were elected members of the Board of Control to fill the vacancies created by the resignations of Colonel Dion Williams, U. S. M. C., and Capt. A. St. Clair Smith, U. S. Navy.

**Membership.**

Life, regular and associate membership, 5779. New members: 20. Resignations: 17.

Deaths:

Rear Admiral Charles H. Manning, U. S. N. Ret.
Ensign J. D. Edwards, U. S. N.

**Dues**

The annual dues ($2.50) for the year 1919 are now payable.

Regular and associate members of the U. S. Naval Institute are subject to the payment of the annual dues until the date of the receipt of their resignation.

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*All members are urged to keep the Secretary and Treasurer informed of the address to which* PROCEEDINGS *are to be sent, and thus insure their receipt.*

Members and subscribers are urged to notify the Secretary and Treasurer promptly of the non-receipt of PROCEEDINGS, in order that tracers may be started. The issue is completed by the 10th of each month.

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The attention of authors of articles is called to the fact that the cost to them of reprints other than the usual number furnished, can be greatly reduced if the reprints are struck off while the article is in press. They are requested to notify the Secretary and Treasurer of the number of reprints desired when the article is submitted. Twenty copies of reprints are furnished authors free of charge.

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Authors of articles submitted are urged to furnish with their manuscript any illustrations they may have in their possession for such articles. The Institute will gladly co-operate in obtaining such illustrations as may be suggested by authors.

Original photographs of objects and events which may be of interest to our readers are also desired, and members who have opportunities to obtain such photographs are requested to secure them for the Institute.

**Notice**

Whole Nos. 6, 7, 10, 13, 14, 15, 17, 145, 146, 147, 149, 155, 166 and 179 of the PROCEEDINGS are exhausted; there are so many calls for single copies of these numbers that the Institute offers to pay for copies thereof returned in good condition at the rate of 50 cents per copy.

ANNAPOLIS, MD., MAY 15, 1919.

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# PROFESSIONAL NOTES

PREPARED BY

COMMANDER S. A. TAFFINDER, U. S. Navy

## GENERAL ARRANGEMENT


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## GERMANY

GERMAN MINE-LAYING CRUISERS.—Among the German warships now in custody at Scapa Flow there are two which invite special attention, representing as they do the sole example of originality in naval design that modern German construction has offered. The vessels in question are the *Bremse* and *Brummer*, officially rated as light cruisers, but possessing certain features that put them in a class by themselves. They are, in fact, high-speed mine-layers, and in the opinion of officers who have surveyed them they are uncommonly useful ships for this work. The *Bremse* (*Anglicè* Gadfly) was launched from the Vulkan yard, Stettin, at midsummer, 1916, and completed before the end of that year. The *Brummer* (Growler) was built by the Schichau yard, at Danzig, and completed in December, 1916. Full details of the ships have still to be published, but their dimensions, etc., are approximately the following: Length on waterline, 435 feet; beam, 43½ feet; mean draft, 16½ feet; displacement, 4150 tons. Machinery: Turbines of Parsons type, driving four screws; 14 Schulz-Thornycroft boilers for mixed firing. Maximum fuel supply, including oil, 850 tons. Designed horse-power 32,000 for a speed of 29.5 knots—on trial a mean of 30.2 knots is said to have been maintained for three hours. It appears, however, that on this occasion the ships were in a light condition, and on service their best reliable speed is said not to exceed 29 knots, though they can make 30 for short spurts. The scantlings are flimsy, judged by ordinary standards, and the limited coal supply presupposes a design framed with a special regard to operations in the Narrow Seas. This is borne out by the fact that the living quarters are very cramped, and the general arrangements for accommodating the crew of 370 are somewhat primitive. The same scrupulous regard for economy in

weight is revealed by an inspection of these vessels above water. In general they differ in appearance from other German light cruisers by having pronounced "clipper" stems, cased in funnels, and the minimum of superstructure. On the forecastle there is a 45-caliber 5.9-inch gun, with shield; a second gun of this size is placed between the first and second funnels on the boat deck; a third on the deckhouse abaft the main mast, with a blast screen projecting well over the quarter deck, where the fourth 5.9-inch gun is situated. This disposition of armament gives a broadside of four 5.9-inch guns, fire ahead being limited to one gun, and two guns training astern. On the boat deck between the third funnel and the mainmast are two 3.4-inch guns on high angle mounts. Above the conning-tower is a fire-control station with a rangefinder. The bridge carries a closed-in chart house constructed of splinter-proof steel, and above is a platform for two large searchlights. Each of the three funnels appears to have a steel glacis at the base as protection against splinters. The after bridge is open, with a single searchlight position above it.

The *Bremse* is reported to have carried 300 mines, but it is not easy to discover where such a large number could have been housed. Two pairs of rails are laid along the quarter deck for transporting the mines to the stern. It is stated, however, that special arrangements exist for releasing mines below water, the object being to deceive hostile scouts or aircraft with regard to the nature of the work on which the vessel was employed when under observation.

At the time of their completion the *Bremse* and *Brummer* were probably the fastest cruisers afloat. In addition to laying mines, they seem to have been used occasionally for raiding convoys in the North Sea, and information from enemy sources credits these two vessels with the principal rôle in the action of October 17, 1917, off the Norwegian coast, when the British destroyers *Strongbow* and *Mary Rose* were lost, together with a number of merchantmen in their convoy. News of the convoy's position and course having been received by wireless from a scouting Zeppelin, the *Bremse* and *Brummer*, with several destroyers, at once left the Baltic and succeeded in intercepting their prey. Steaming at high speed, and using their 5.9-inch guns, the cruisers were able to make short work of the two destroyers and the unarmed merchantmen, after which they withdrew before pursuit could become effective.

It is rather doubtful whether further ships of this type exist. Two other units are said to have been built, viz., *Hummel* (Bumble-bee) and *Wespe* (Wasp), but the report cannot be confirmed. The only ships previously built in Germany for the special duty of mine-laying were the *Nautilus* and *Albatross*, launched in 1906 and 1907 respectively. They displace 1950 to 2200 tons, and can steam at 20 knots. Another of the few existing vessels of this type is the Swedish mine-layer *Claes Fleming*, completed in 1915. She is of 1748 tons, and has a speed slightly above 20 knots. In our own navy it has not been deemed necessary to design ships specially for mine-laying, which during the war was carried out by vessels of almost every description, from battleships to submarines. Several flotilla leaders and a number of the larger destroyers were temporarily fitted up as mine-layers. The *Abdiel*, a flotilla leader launched at Birkenhead in 1915, was attached to the Grand Fleet as a "flying mine-layer," and in this capacity made things very unpleasant for the retreating German fleet after the Battle of Jutland. At the other end of the scale is the battle-cruiser *Courageous*, which is equipped with gear for sowing mines. Of the six old cruisers of the *Apollo* class, that were reconstructed as mine-layers before the war, several were scuttled as block ships on the Belgian coast, and the remaining vessels are now out of service.—*The Engineer*, 4/18.

A dispatch from Berlin states that Baron Gemingen, nephew and successor of Count Zeppelin, intends to attempt to cross the Atlantic in the Zeppelin dirigible known as the *Z-72*. The armistice conditions prevent the completion of the airship, on which about two weeks' work is required.

The cruiser is 715 feet long with a diameter of more than 60 feet. She will have seven motors of 240 horse-power each. Her gas capacity will approximate 2,000,000 cubic feet. Baron Gemingen estimates that the distance from Friedrichshaven to Washington can be covered in 68 hours, depending upon the weather. It is asserted in Zeppelin circles that under favorable conditions the new airship could make the round trip without landing.—*Aerial Age Weekly*, 5/5.

## GREAT BRITAIN

H. M. BATTLE CRUISERS "REPULSE" AND "RENOWN."—In the early months of the war the need for additional battle cruisers of very high speed and armed with big guns, became more and more apparent, both to deal with raids on our coasts by enemy battle cruisers and with possible raids further afield. The value of this type of ship was also most clearly demonstrated at the Battle of the Falkland Isles. The British Admiralty therefore decided on the advice of Lord Fisher in January, 1915, to lay down a new type of cruiser, of great length and limited draft, and of very much increased speed, to meet this need. The battle cruisers *Repulse* and *Renown* were therefore ordered, the former from Messrs. John Brown and Co., Ltd., Clydebank, and the latter from the Fairfield Shipbuilding and Engineering Company, Ltd., Glasgow, at the beginning of January, 1915. Both ships are alike in every respect, and were the largest and most noteworthy warships added to the British fleet during the war. The vessel was successfully launched on January 8, 1916.

The *Repulse* left Clydebank Yard, a commissioned ship, on August 14, 1916, or in 19½ months from the date when the requisite information was received by Messrs. John Brown and Co., and the Fairfield Company to proceed with the detailed drawings in conjunction with the Admiralty officials, and to send out orders for material.

On a preliminary run to Ailsa Craig immediately after the vessel reached the Tail-of-the-Bank, the machinery was gradually worked up to 107,000 s. h. p., and on the following day, during the four hours' trial, the mean horse-power developed for the first two hours was 117,000 and for the subsequent two hours 121,000. Further trials were carried out in the Firth of Clyde when the vessel was loaded to about 30,000 tons' displacement, and over a measured course a speed of nearly 32 knots was attained, the machinery developing over 119,000 s. h. p.

The *Repulse* was the largest and most powerful warship in the world at the time, her length being 790 feet, breadth 90 feet, and depth to upper deck 41 feet, with a normal displacement of about 27,000 tons. The great length in proportion to depth gives the appearance of a large type of light cruiser rather than a battle cruiser, but on closer examination, the two barbettes, each having a pair of 15-inch guns highly mounted for ahead attack, equal in power to those fitted in the super-dreadnoughts, and a similar pair of 15-inch guns mounted in a turret aft, give a strong impression of the great size of the vessel. These guns are each arranged to train through 150 degrees on either side of the middle line, and give a concentrated broadside fire, equal to 75 per cent of that of the latest battleships, thus making the vessel very powerful in attack.

The secondary armament consists of seventeen 4-inch B. L. guns, 15 of these being arranged on triple mountings, two sets on the conning-tower platform level on each side of the forward funnel, and three sets on the

middle line on the flying and the shelter deck level. The single 4-inch B. L. guns are placed on the shelter deck, on each side abreast of the conning-tower, with a training sweep of 155 degrees. Two 3-inch high-angle guns are mounted on pedestals on the shelter deck abreast after the funnel, four 3-pdr. Q. F. guns on the same deck abreast the forward funnel, and five machine guns. In conjunction with these guns, there are fitted on platforms attached to the funnels six 36-inch single searchlight projectors, two similar projectors on the compass platform, and two 24-inch single signalling searchlights at the after end of the conning-tower platform. The vessel is fitted with two 21-inch under-water broadside torpedo tubes, placed in a compartment between the platform and the lower deck forward of the forward magazine; stowage is provided for ten torpedoes.

The conning-tower is of oval form, having armour 10 inches thick, with an inner gun control tower with revolving hood and armored rangefinder. An armored torpedo control tower, with revolving hood and rangefinder for controlling the fire of the torpedoes, is placed on the after flying deck. In addition to these towers, which are situated in commanding positions, there are fitted on the foremast high above the navigating platforms a spotting top, a 15-inch gun director platform, and a 4-inch gun director platform; also a director platform and rangefinder for anti-aircraft guns on the main mast; and a signal distributing station in the armored house on the shelter deck under the main conning-tower. The intelligence and de-coding offices are in similarly protected houses placed on the forecastle and shelter decks respectively.

The vessel is minutely sub-divided, having six boiler rooms, four engine rooms, and a cellular double bottom, extending from the middle line around the side and under the main or protective deck. A longitudinal bulkhead forming the boundary of the oil tanks extends alongside the engine rooms, boiler rooms and magazines, with an inner bulkhead forming an air space for the extent of the boiler rooms.

The armor consists of a main belt about 9 feet 6 inches wide extending from abreast the after barbette to forward, and aft of these positions for a further length of 84 feet forward, and 62 feet aft of reduced thickness. The armor belt is finished off by a transverse armor bulkhead forward and aft, and two additional transverse armor bulkheads are fitted to resist end on fire. The maximum thickness of the armor of the barbettes is 7 inches. The forward conning-tower armor is 10 inches thick, and the torpedo control tower 3 inches thick. The main or protective deck is 2 inches thick on the slopes with an additional strake of 2 inches high-tension protective plating in the vicinity of the water-line. The lower deck aft is 3½ inches thick over steering gear.

Structurally, the vessel is very substantially built, the shell plating of the topsides and the forecastle deck consisting of two thicknesses of high tensile steel of a total thickness of 1½ inches, and the bottom plating is generally 1 inch thick, tapered at the ends.

The chart house, admiral's and captain's sea cabins, navigating officer's cabin, are situated on the platform and shelter deck forward. The *Repulse* was completed as a flagship, the admiral's cabins being in the deck house on the after end of the forecastle deck. The ward room, captain's cabins, and principal officers' accommodation, offices, etc., are on the upper deck aft. The gun room and junior officers' cabins are placed on the main deck aft of midships. The mess decks for the crew are on the upper deck amidships and forward, and on the main deck amidships; the sick bay and operating rooms, and lavatories in connection therewith, are on the upper deck forward; the wash places for crew are on the main deck abreast the boiler rooms and forward.

The equipment of the vessel is very complete; the electric generating machinery consists of two sets of steam-driven reciprocating engines, each of 200 kw.; one turbo and one Diesel engine-driven generators of equal power placed in separate compartments forward and aft; electric boat winches, ammunition and deck winches; warping capstan; auxiliary steering gear; ventilating fans for machinery spaces and for working compartments and living quarters; electric heating for cabins, magazine cooling and icemaking plant; electric pumps for fresh water and bilge purposes; three sets of wireless installation; eight lifts for engine and boiler rooms; electric power for driving workshop machinery; a very complete installation of telephones and alarm bells; also the electrical equipment in connection with fire control, transmission of range and training of guns, danger signals, torpedo control and firing gear, and gyrocompasses. The capstan engines and cable holders are of the usual steam-driven type for the forward cable gear. The steam steering engines, controlled by telemotors, are placed on the after bulkhead in the engine room, and are connected up by shafting and gearing to a powerful set of screw steering gear operating a single balanced rudder.

The propelling machinery consists of Brown-Curtis turbines driving four shafts, two on each side of the ship. They are the largest direct-drive turbines built in the world.

The turbines are placed in two engine rooms side by side, divided by a middle-line bulkhead. In each engine room are three turbines driving the two shafts, the high pressure ahead and low pressure ahead being on the inner shaft and rigidly connected with each other, and the intermediate pressure ahead on the wing shaft. Incorporated in the same casing as the intermediate pressure ahead turbine is a high pressure astern turbine and with the low pressure ahead turbine is a low pressure astern turbine. In this view there is seen alongside the low pressure turbine for a geared set of about three-fourths of the power and the effect on size of increasing the number of revolutions where gearing is fitted between the turbine and propeller will be appreciated.

The high pressure ahead turbine consists of two wheels, each carrying three rows of blades, the pitch circle diameter of these blades being 10 feet 6 inches. The intermediate pressure ahead turbine consists of two stages of two rows of blades each, and a short drum of 12 rows of blades; then a second portion of two stages of two rows each; and a drum of 31 rows. The pitch circle diameter of these varies from 9 feet 3 inches to 10 feet. The low pressure ahead rotor consists of a drum portion of 34 rows, with a pitch circle diameter of 12 feet. The last blades are 26 inches in length and 1⅜ inches wide.

The astern turbines consist of two stages of four rows each and a drum of six rows forming the high pressure astern turbine and a wheel of three rows and a drum of nine rows forming the low pressure astern turbine. The pitch circle diameter of the high pressure astern turbine is 10 feet and of the low pressure astern 11 feet.

The propeller thrust in each case is nearly balanced by the steam thrust arranged in the turbine, so that no main thrust block is necessary, but only a comparatively small block on each line of shafting. Each of these blocks has a thrust surface of 4370 square inches on 16 collars. In order to obtain this balance in the intermediate pressure turbine, one of Mr. Curtis' latest patents was introduced, namely, to take the steam a short distance along the turbine, passing it in the forward direction, and then, by external passages, to cause it to re-enter the turbine and to travel aft for the remainder of the length of the rotor.

The intermediate shafting is 18½ inches diameter with an 11-inch hole, and the propeller shafts are 24 inches diameter with a 19-inch hole,

these being cased with gunmetal liners in the stern tubes and main brackets.

The condensers, two for each set of engines, are placed in two compartments, immediately aft of the main engine rooms, with the eduction pipes passing through the transverse bulkhead. The surface of each condenser is 19,225 square feet, or a total of 76,900 square feet for all the condensers. In the condenser room are the main circulating pumps, two per set of main engines, the evaporators and distillers, etc. The main air pumps are in the main engine room, so as to be under the control of the engineer of the watch. The forced lubrication pumps for the turbine bearings are also in the engine rooms, together with the necessary oil coolers, filters, etc., while the smaller forced lubrication pumps, coolers, etc., for the shaft bearings are in the condenser rooms.

Steam is supplied by 42 boilers of the Babcock and Wilcox type, these being entirely oil fuel fired and working at a pressure of 250 pounds per square inch. The total combustion chamber space of the boilers is 23,310 cubic feet, and the total heating surface of all the boilers is 157,206 square feet. The boilers are all alike, each of 22 sections wide, 8 feet 1 inch between headers. The bottom tubes are $3\frac{1}{8}$ inches external diameter each and the remainder of the tubes $1\frac{1}{8}$ inches external diameter. The vessel has two funnels, the forward one serving 22 boilers and the after one 20 boilers. The forward funnel is 25 feet by 16 feet 6 inches and the after one is 13 feet by 16 feet 6 inches.—*Engineering*, 4/11.

H. M. SEAPLANE-CARRYING SHIP "ARGUS."—One of the most interesting ships added to the navy during the war was the seaplane-carrying ship *Argus*, built by Messrs. William Beardmore and Co., Limited, at their works at Dalmuir on the Clyde. It is true that the Admiralty adapted the battle cruiser *Furious* to accommodate seaplanes and to permit them to rise from the deck, and this vessel, with her 90,000-h. p. geared turbine machinery, had a speed of 32 knots, which gave her a great advantage over the *Argus* in point of speed. Further, there is now being built specially for the same duty the cruiser *Eagle*, also of high speed and specially adapted to enable seaplanes to rise from her deck. The *Argus*, however, has the advantages that there is absolutely no obstruction on the flying deck, not even funnels, and that she has under this deck space for the accommodation and repair of seaplanes. She is therefore a floating hangar, the space given up for this purpose being 330 feet long, 68 feet wide over all, and 48 feet clear, with a clear height of about 20 feet. Hoists are provided from this hangar to the flying deck, and cranes are available for lifting the seaplanes from the water on to the hangar deck. The structural arrangements in the ship to meet these abnormal conditions involved problems of design and construction which were admirably worked out and proved thoroughly successful. Perhaps, however, the most novel feature is the arrangement of the uptakes from the funnels, so that the boiler furnace gases could be discharged over the stern. Here also gratifying success has been achieved, and the results reflect credit not only on the technical officers of the Admiralty, but on those responsible for the building of the ship and her machinery at Messrs. Beardmore's works.

In the early stages of the design of the superstructural work the method of supporting the flying deck was carefully considered. A ¼-inch scale model of the ship according to the proposed method of construction was sent to the National Physical Laboratory at Teddington to be tested in the air tunnel there. Exhaustive experiments on this model were carried out for the purpose of discovering the eddy-making effect of the structural work below and above the flying deck, and also about the after end,

through which air eddies the aircraft had to pass when alighting on the deck. The result of these experiments showed that to ensure the minimum of air disturbance it was necessary that the space between the hangar roof and flying deck should be as open as possible. On account of this it was decided to make the hangar roof strong enough to withstand the greatest hogging and sagging stresses likely to come on the structure and to support the flying deck by very light lattice work. In addition, expansion joints were introduced at various points to ensure that no stresses were to be taken up by the flying deck. Further, it was discovered that the emission of the hot gases through vertical funnels above the flying deck produced such serious air disturbance that the safe landing on the deck would be extremely difficult. This necessitated the fitting of the horizontal smoke ducts below the flying deck which carry the gases right aft away from the stern.

The hangar, designed to fulfill the latest requirements of the Air Board for this type of ship, is 330 feet long by 68 feet wide over all, and 48 feet clear width, and is of a capacity regarded as sufficient to accommodate 20 seaplanes.

The flying deck is 68 feet wide, is fitted all fore and aft at a distance of 14 feet 6 inches above the hangar roof, and is clear of all obstructions. The navigating bridge, bridge houses, wireless offices, etc., are placed forward under the flying deck. The chart house is capable of being raised above the flying deck level or lowered to a stowing position under the flying deck by hydraulic power, and when in raised position commands a clear all-round view.

There are two electrically-controlled lifts for raising the aeroplanes from the hangar to the flying deck. The after lift is 60 feet long by 18 feet wide, and the forward lift 30 feet long by 36 feet wide, and each is capable of lifting the largest Service planes with the wings folded back. These planes on reaching the flying deck have their wings extended and are then ready for flight. The total deck opening in way of the forward hatch is 56 feet. When the lift is at the flying deck level two roller platforms, each 10 feet wide, slide to the sides and thus completely cover the well openings. When the lift is below the flying deck these platforms are brought into the center and give a 20-foot starting platform for the run off. It was intended that aeroplanes should alight on the after part of the flying deck, and to facilitate this at night, special illuminating arrangements are provided for the guidance of pilots. In addition to the lamps at each side and across the flying deck aft to guide planes landing on the deck at night, steam jets are fitted forward at each side and at the stem for guidance in maneuvering for aircraft during daylight. On the flying deck aft a special arrangement is fitted in the form of wire mattresses, for retarding aircraft when landing. Planes that have landed in the water are specially picked up by means of two derricks with electric winches placed amidships on the flying deck, and two electric cranes abaft the hangar on the hangar deck. In addition to the stowage arranged for aircraft in the hangar, provision is made for carrying aircraft on the flying deck. When aircraft are thus stowed on the flying deck, a timber palisading can be raised around this deck to act as a wind screen. The palisades are arranged in such a manner that they can be raised simultaneously 14 feet above the deck level, and are lowered simultaneously to the flush of the flying deck. All erections on the flying deck, such as navigating and chart house jack and ensign staffs, poles for navigating and signalling lights, are arranged so that all can be lowered flush with the flying deck.

Two signal and wireless telegraphy masts are arranged so that they can be lowered flush with the flying deck having special contrivances and

winches for overhauling all slack rigging; this also applies to rangefinder and gun control instruments for use with anti-aircraft guns. Outside and around the flying deck is fitted a wide safety net.

The armament of the vessel consists of four 4-inch guns of special type for anti-aircraft and anti-submarine protection, and two 4-inch Q. F. guns. These are placed in suitable positions forward, amidships, and aft so as to afford all-round and overhead protection.—*London Engineering*, 3/28.

## BATTLESHIPS AND BATTLE CRUISERS

*(Dreadnoughts and later ships only)*

NUMBER OF GUNS OF MAIN ARMAMENT ON BRITISH *v.* GERMAN

| | August 4, 1914 | | Added during the war, less losses | | | |
|---|---|---|---|---|---|---|
| | | | Up to May 31, 1916 | | Up to November 11, 1918 | |
| | British | German | British | German | British | German |
| 15 in. | .... | .... | 64 | 8 | 100 | 16 |
| 14 in. | .... | .... | 10 | .. | 10 | .. |
| 13.5 in. | 124 | .... | 28 | .. | 20 | .. |
| 12 in. | 148 | 184 | 14 | 48 | minus 12 | 56 |
| 11 in. | | | | | | |
| Total | 272 | 184 | 116 | 56 | 118 | 72 |
| Weight of broadside | 279,100 lb. | 116,600 lb. | 190,340 lb. | 52,840 lb. | 226,600 lb. | 77,500 lb. |

We also had 12-inch, 14-inch, and 15-inch guns on monitors, but these are not taken into account in the above table, nor are guns on pre-dreadnoughts counted.

The above table shows that at the beginning of the war we had in our capital ships, dreadnoughts and battle cruisers 272 (German 184), big guns with a total broadside of 279,100 pounds (German 116,600 pounds), and by the end of the war we had added one hundred 15-inch guns, besides 13.5-inch, etc., and a net addition of 226,600 pounds broadside against sixteen 15-inch and fifty-six 12-inch with a broadside of 77,500 pounds to the German Navy.

We began with an advantage of 140 per cent weight of broadside.

At Jutland we had an advantage of 175 * per cent weight of broadside.

At finish we had an advantage of 160 per cent weight of broadside.

WAR DEVELOPMENT OF BRITISH TORPEDO-BOAT DESTROYER.—During the period of active hostilities—August 4, 1914, to November 11, 1918—25 flotilla leaders and 280 torpedo-boat destroyers were completed and delivered to the government by 16 British shipyards. Of this total of 305 vessels, eight Clyde firms contributed no less than 156.

* If two ships of *Royal Sovereign* type only just commissioned are not counted, above percentage becomes 160.

The above figures only include the British and the German Fleets; no account is taken of any of the Allied Fleets or of the Enemy Allied Fleets.—*From "Naval Construction during War," by Sir Eustace Tennyson D'Eyncourt, K. C. B., read before Institution of Naval Architects April 9, 1919.*

The progress made in the adoption of geared turbines for all classes of torpedo-boat destroyers is shown by the following figures, which give the number of vessels fitted with geared turbines delivered from August 4, 1914, to end of each year: To end of 1914, 2 destroyers; to end of 1915, none; to end of 1916, 15 destroyers; to end of 1917, 2 leaders, 59 destroyers; to November 11, 1918, 6 leaders, 62 destroyers; giving totals of 8 leaders and 148 destroyers respectively.

The *Shakespeare* was, like the *Spencer* and *Wallace*, the largest unit built by Messrs. Thornycroft for the Admiralty, and the geared turbines were designed to meet the guaranteed speed of 35 knots. The particulars of the vessels are as follows: Length on water-level, 325 feet 9 inches; beam, 31 feet 9 inches; depth, 19 feet 9 inches; armament, five 4.7 guns, one 3-inch H. A. gun, six 21-inch torpedo tubes and two depth-charge throwers. The oil fuel capacity is 500 tons, and the complement 157 men. The displacement with all oil on board is just under 2000 tons. The speed of the *Shakespeare* on official trial, which was run in the Channel, was tested by four runs over a 20 fathoms course, the ship being in fully-equipped condition with all armament and ammunition, but with 3 hours' oil fuel only on board, representing her condition in the middle of a 6 hours' full-power trial. The speed obtained in this depth of water was 38.95 knots.—*Engineering*, 3/21.

BULGE PROTECTION BRITISH SHIPS.—Immediately after the outbreak of war, Sir Eustace d'Eyncourt put forward proposals for what is now termed "bulge" protection for ships. Experiments were made, and his ideas proved to be correct, and bulges were fitted to some of the old cruisers of the *Endymion* class, and to the new large monitors mounting heavy guns. This protection consisted of a water-tight outer compartment full of air and an inner compartment open to the sea, and therefore full of water. It was a long time before any vessel fitted with this arrangement was actually torpedoed, but in the end several vessels with bulges were torpedoed, and survived.—*London Engineering*, 4/18.

BRITISH NAVAL RESERVOIR.—The large reservoir constructed at Rosyth for the storage of oil fuel for the British Navy has now been completed, and the two sections in which it is built have a combined capacity of sixty million gallons, the area occupied by the reservoir and surrounding roadway, pipe track, etc., is 11¼ acres, and the roof area is 7½ acres. The reservoir is built of concrete on a rock foundation, the site being the sandstone quarry known as Howe Cove. The final testing was carried out by pumping salt water into the reservoir from the Firth of Forth at the rate of 4000 gallons per minute.—*London Army and Navy Gazette*, 4/5.

CHANGES IN BRITISH SHIPS AFTER JUTLAND.—After the Battle of Jutland a considerable amount of additional protection was added over the magazines in practically all our ships as a precautionary measure. Only in one case was any portion of a shell found to have penetrated below the protective deck, but with the ever-increasing range at which actions have been fought, and the increasing penetration of improved shell, the danger of the decks being inadequate had to be considered. In certain ships, the under-water protection was reinforced by adding outside bulge protection.—*London Army and Navy Gazette*, 4/12.

## British Naval Construction During the War

### TABLE I

| | Battleships | | | | | | Battle cruisers | | Large light cruisers | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Iron Duke | Queen Elizabeth | Royal Sovereign | Agincourt | Erin | Canada | Tiger | Renown | Courageous | Furious |
| Length between perpendiculars | 580ft. | 600ft. | 580ft. | 632ft. | 525ft. | 625ft. | 660ft. | 750ft. | 735ft. | 750ft. |
| Length overall | 622ft. 9in. | 643ft. 9in. | 624ft. 3in. | 671ft. 6in. | 559ft. 6in. | 661ft. | 704ft. | 794ft. | 786ft. 3in. | 786ft. 6in. |
| Breadth, extreme | 90ft. | 90ft. 6in. | 88ft. 6in. | 89ft. | 91ft. 7in. | 92ft. | 90ft. 6in. | 90ft. | 81ft. | 88ft. |
| Load draft, mean | 28ft. | 28ft. 9in. | 28ft. 6in. | 27ft. | 28ft. 6in. | 28ft. 6in. | 28ft. 6in. | 25ft. 6in. | 22ft. 3in. | 21ft. 6in. |
| Displacement in tons | 25,000 | 27,500 | 25,750 | 27,500 | 23,000 | 28,000 | 28,500 | 26,500 | 18,600 | 19,100 |
| Shaft horsepower of engines | 29,000 | 75,000 | 40,000 | 34,000 | 26,500 | 37,000 | 108,000 | 112,000 | 90,000 | 90,000 |
| Speed at load draft, knots | 21 | 25 | 23 | 22 | 21 | 22¼ | 30 | 32(nearly) | 32 | 31½ |
| Fuel at load draft, tons | 900 | 650 | 900 | 1500 | 900 | 1150 | 900 | 1000 | 750 | 750 |
| Coal capacity, tons | 3250 | .... | .... | 3200 | 2120 | 3300 | 3320 | .... | .... | .... |
| Oil fuel capacity, tons | 1050 | 3400 | 3400 | 620 | 710 | 520 | 3480 | 4250 | 3250 | 3400 |
| Armament | 10 13.5in.<br>12 6in.<br>4 21in. T.T. | 8 15in.<br>12 6in.<br>4 21in. T.T. | 8 15in.<br>14 6in.<br>4 21in. T.T. | 14 12in.<br>20 6in.<br>2 21in. T.T. | 10 13.5in<br>16 6in.<br>4 21in. T.T. | 10 14in.<br>14 6in.<br>4 21in. T.T. | 8 13.5in.<br>12 6in.<br>4 21in. T.T. | 6 15in.<br>17 4in.<br>2 21in. T.T. | 4 15in.<br>18 4in.<br>14 21in. T.T. | ....<br>10 5.5in.<br>18 21in. T.T. |
| Armour— | | | | | | | | | | |
| Side, amidships | 12in., 9in., 8in. | 13in., 6in. | 13in., 6in. | 9in., 6in. | 12in., 9in., 8in. | 9in., 7in., 4½in. | 9in., 6in., 5in. | 6in., 1½in. | 3in. | 4in. |
| Side, forward and aft | 6in., 4in. | 6in., 4in. | 6in., 4in. | 6in., 4in. | 6in., 4in. | 6in., 4in. | 4in. | 4in., 3in. | 2in. forward | 2in. forward |
| Bulkheads, forward and aft | 8in., 6in., 4in. | 6in., 4in. | 6in., 4in. | 6in., 3in. | 8in., 5in., 3in. | 4½in., 4in. | 4in., 2in. | 4in., 3in. | 3in., 2in. | 3in., 2in. |
| Barbettes | 10in. to 3in. | 10in. to 4in. | 10in. to 4in. | 9in. to 3in. | 10in. to 3in. | 10in. to 4in. | 9in. to 3in. | 7in. to 4in. | 7in. to 3in. | 7in. to 3in. |
| Gun-houses | 11in. | 11in. | 11in. | 12in., 8in. | 11in. | 10in. | 9in. | 11in. to 7in. | 9in., 7in. | 7in. |
| Conning-tower | 11in. | 11in. | 11in., 6in. | 12in. | 12in. | 11in. | 10in. | 10in. | 10in. | 10in. |
| Protection— | | | | | | | | | | |
| Vertical plating | 1½in., 11n. | 2in., 11n. | 1½in., 11n. | 1½in., 11n. | 1½in. | 2in., 1½in. | 2½in., 1½in.<br>11n. | 1½in. | 1½in., 11n. | 11n. |
| Forecastle deck | 11n.<br>amidships | 11n. | 11n. | 1½in.<br>amidships | 1½in.<br>amidships | 11n.<br>amidships | 1½in., 11n. | 1½in., 1½in. | 11n. | 11n. |
| Upper | 2in. to 1½in. | 2in. to 1½in. | 1½in. to 1½in. | 1½in. | 1½in. | 1½in. | 1½in., 11n. | ½in. | 11n. | 11n. |
| Main | 1½in. at ends | 1½in. at ends | 2in., 1½in., 11n. | 1½in., 11n.<br>at ends | 1½in. | 1½in. aft | 11n. at ends | 3in. to 11n. | 1½in., ½in. | 1½in., ½in. |
| Middle | 2½in., 11n. | 11n.<br>amidships | 2in. slope<br>main to middle<br>11n., 2½in.,<br>3in., 4in. | 1½in., 11n. | 3in., 11n. | 11n. | .... | .... | .... | .... |
| Lower | 2½in., 11n. | 3in., 11n. | | 2½in., 11n. | .... | 4in., 2in. | 3in., 11n. | 2½in. | 3in., 11n. | 3in., 11n. |

**TABLE I.—Continued**

| | Light cruisers | | | | Monitors | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arethusa | Callipode | "D" class | Raleigh | Humber | 14in. gun class | 12in. gun class | Marshal Soult | Erebus | 9.2in. gun class | 6in. gun class |
| Length between perpendiculars | 410ft. | 420ft. | 445ft. | 565ft. | 261ft. 6in. | 320ft. | 320ft. | 340ft. | 380ft. | 170ft. | 170ft. |
| Length overall | 436ft. | 446ft. | 471ft. | 605ft. | 266ft. 9in. | 334ft. 6in. | 335ft. 6in. | 355ft. 8in. | 405ft. | 177ft. | 177ft. |
| Breadth, extreme | 39ft. | 41ft. 6in. | 46ft. | 65ft. | 49ft. | 90ft. | 87ft. | 90ft. 3in. | 88ft. | 31ft. | 31ft. |
| Load draft, mean | 13ft. 6in. | 13ft. 6in. | 14ft. 3in. | 17ft. 3in. | 4ft. 9in. | 10ft. | 10ft. | 10ft. 3in. | 11ft. | 6ft. | 4ft. |
| Displacement in tons. | 3500 | 3750 | 4650 | 9750 | 1260 | 6150 | 5900 | 6670 | 8000 | 540 | 355 |
| Shaft horsepower of engines | 40,000 | 40,000 | 40,000 | 60,000 | 1450 | 2000 | 2300 to 2500 | 1500 | 6000 | 480 to 800 | 400 |
| Speed at load draft, knots | 29 | 29 | 29 | 30 | 12 | 6 to 7 | 6 to 7 | 6 to 7 | 12 | 12 to 13 | 10 |
| Fuel at load draft, tons | 260 | 300 | 300 | 1000 | 50 | 200 | 200 | 100 | 220 | .... | .... |
| Coal capacity, tons | .... | .... | .... | 800 | 187 | 400 | 350 | .... | .... | .... | .... |
| Oil fuel capacity, tons | 810 | 920 | 1050 | 1600 | 90 | .... | .... | 235 | 750 | 30 | 45 |
| Armament | 2 6in.<br>7 4in. (1 H.A.)<br>8 21in. T.T. | 2 6in.<br>8 4in.<br>4 21in. T.T. | 6 6in.<br>2 3in. H.A.<br>12 21in. T.T. | 7 7.5in.<br>12 3in. (4 H.A.)<br>6 21in. T.T. | 3 6in.<br>2 4.7in. howitzers<br>.... | 2 14in.<br>1 6in.<br>.... | 2 12in.<br>1 to 4 6in.<br>.... | 2 15in.<br>8 4in.<br>.... | 2 15in.<br>8 4in.<br>.... | 1 9.2in.<br>1 3in.<br>.... | 2 6in.<br>1 6-pdr.<br>.... |
| Armour— | | | | | | | | | | | |
| Side, amidships | 3in. | 3in. | 3in. | 3in., 2in. | .... | .... | .... | .... | .... | .... | .... |
| Side, forward and aft | 2in., 1½in. | 2in., 1½in. | 2in., 1½in. | 2½in., 1½in. | .... | .... | .... | .... | .... | .... | .... |
| Bulkheads, forward and aft | .... | .... | 1½in. 1in. aft | 1in. aft | .... | 4in. | 6in. | 4in. | 4in. | .... | .... |
| Barbettes | .... | .... | .... | .... | .... | 8in. to 2in. | 8in. to 2in. | 8in. | 8in. | .... | .... |
| Gun-houses | .... | .... | .... | .... | .... | 10in., 7in., 4in. | 10½in., 5½in., 4in., 2in. | 13in., 11in. 4½in. | 13in., 11in. 4½in. | .... | .... |
| Conning-tower | 6in. | 6in. | .... | 3in. | .... | 6in. | 6in. | 6in. | 6in. | .... | .... |
| Protection— | | | | | | | | | | | |
| Vertical plating | .... | .... | .... | .... | .... | 1½in. | 1in. | 1in. | 1in. | .... | .... |
| Forecastle deck | .... | .... | .... | .... | .... | 1in. | 1in. | 1in. | 1in. | .... | .... |
| Upper | 1in. amidships | 1in. amidships | 1in. amidships | 1in. amidships | .... | 2in. to 4in. on slope | 2in. to 6in. on slope | 1½in., 2in. to 4in. on slope | 2in. to 4in. on slope | .... | .... |
| Main | .... | .... | .... | .... | .... | 1½in., 1in. | 1½in. 1in. | 1½in., 1in. | 1½in., 1in. | .... | .... |
| Lower | 1in. aft | 1in. aft | 1in. aft | 1in. aft | .... | .... | .... | .... | .... | .... | .... |

TABLE I.—Continued

| | Torpedo-boat destroyers | | | T. B. D. flotilla leaders | | Patrol boats | Sloops and mine-sweepers | | | "China" gunboats | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | "M" class | "R" and "S" classes | "V" and "W" classes | Kempenfelt class | Scott class and Shakespeare class * | "P" class | Single-screw sloops. "Flower" class | Paddle mine-sweepers | Twin-screw mine-sweepers | "Fly" class | "Insect" class |
| Length between perpendiculars | 265ft. | 265ft. | 300ft. | 315ft. | 320ft. | 230ft. | 255ft. 3in. | 235ft. | 220ft. | 120ft. | 230ft. |
| Length overall | 273ft. 4in. | 276ft. | 312ft. | 325ft. | 332ft. 6in. | 244ft. 6in. | 267ft. 9in. | 245ft. 9in | 231ft. | 126ft. | 237ft. 6in. |
| Breadth, extreme | 26ft. 8in. | 26ft. 8in. | 29ft. 6in. | 31ft. 9in. | 31ft. 9in. | 23ft. 9in. | 33ft. 6in. | 29ft. (58ft. over paddles) | 28ft. | 20ft. | 36ft. |
| Load draft, mean | 8ft. 8in. | 9ft. | 9ft. | 10ft. | 10ft. 6in. | 7ft. 7in. | 11ft. | 6ft. 9in. | 7ft. | 2ft. | 4ft. |
| Displacement in tons | 1025 | 1065 | 1300 | 1650 | 1800 | 573 | 1250 | 810 | 750 | 98 | 645 |
| Shaft horsepower of engines | 25,000 | 27,000 | 27,000 | 36,000 | 40,000 to 44,000 | 4000 | 2400 | 1400 | 1800 | 175 | 2000 |
| Speed at load draft, knots | 34 | 36 | 34 | 34 | 36 | 22 | 17 | 15 | 16 | 10 | 14 |
| Fuel at load draft, tons | 140 | 150 | 185 | 255 | 250 | 50 | 130 | .... | .... | .... | .... |
| Coal capacity, tons | .... | .... | .... | .... | .... | .... | 260 | 150 | 140 | 5 | 35 |
| Oil fuel capacity, tons | 280 | 300 | 370 | 515 | 500 | 93 | .... | .... | .... | 10 | 54 |
| Armament | 3 4in. | 3 4in. | 4 4in. or 4.7in. | 4 4in. | 5 4.7in. | 1 4in. | 2 4in. or 4.7in. | 1 3in. | 1 3in. | 1 4in. | 2 6in. |
| | 1 2-pdr. | 1 2-pdr. | 1 3in. | 2 2-pdrs. | 1 3in. H.A. | 1 2-pdr. | 2 3-pdrs. | 1 6-pdr., 2 2-pdrs. | 1 6-pdr., 2 2-pdrs. | 1 3in. | 2 3in. |
| | 4 21in. T.T. | 4 21in. T.T. | 4 or 6 21in. T.T. | 4 21in. T.T. | 6 21in. T.T. | 2 14in. T.T. | .... | .... | .... | 1 6-pdr. .... | .... |

* Approximately same.

TABLE I.—Continued

| | Submarines | | | | | |
|---|---|---|---|---|---|---|
| | "E" class | "G" class | "H" class | "J" class | "K" class | "L" class |
| Length between perpendiculars | 180ft. | 185ft. | 164ft. 6in. | 270ft. | 334ft | 222ft. |
| Length overall | 181ft. | 187ft. | 171ft. | 275ft. | 338ft. | 231ft. |
| Breadth, extreme | 22ft. 6in. | 22ft. 6in. | 15ft. 9in. | 23ft. | 26ft. 6in. | 23ft. 6in. |
| Load draft, mean | 12ft. 6in. | 13ft. 3in. | 11ft. 3in. | 14ft. | 16ft. | 13ft. 6in. |
| Displacement in tons, surface | 660 | 700 | 440 | 1210 | 1880 | 890 |
| Displacement in tons, submerged | 800 | 975 | 500 | 1820 | 2650 | 1070 |
| Shaft horsepower of engines, surface | 1600 | 1600 | 480 | 3600 | 10,000 | 2400 |
| Shaft horsepower of engines, submerged | 840 | 840 | 320 | 1350 | 1400 | 1600 |
| Speed at load draft, knots, surface | 15 | 14 | 13 | 19 | 24 | 17½ |
| Speed at load draft, knots, submerged | 10 | 10 | 10½ | 9½ | 9 | 10½ |
| Oil fuel capacity, tons | 45 | 44 | 16 | 91 | 200 | 76 |
| Armament | 1 3in. | 1 3in. | .... | 1 3in. or 4in. | 1 4in., 1 3in. H.A. | 1 3in. or 4in. |
| | 5 18in. T.T. | 4 18in., 1 21in. T.T. | 4 21in. T.T. | 6 18in. T.T. | 8 18in. T.T. | 6 18in. T.T. |

*From "Naval Construction during War," by Sir Eustace Tennyson D'Eyncourt, K. C. B.; read before Institution of Naval Architects, April 9, 1919.*

## UNITED STATES

### NAVY DEPARTMENT—BUREAU OF CONSTRUCTION AND REPAIR

VESSELS UNDER CONSTRUCTION, UNITED STATES NAVY—DEGREE OF COMPLETION, APRIL 30, 1919

| Type, number and name | Contractor | Per cent of completion | | | |
|---|---|---|---|---|---|
| | | May 1, 1919 | | Apr. 1, 1919 | |
| | | Total | On ship | Total | On ship |
| *Battleships* | | | | | |
| 43 Tennessee | New York Navy Yard | 72.6 | 68.6 | 68.4 | 64.4 |
| 44 California | Mare Island Navy Yard | 59.9 | 48.9 | 57.2 | 45.9 |
| 45 Colorado | New York S. B. Co | 20.4 | 3.4 | 16.4 | 2.1 |
| 46 Maryland | Newport News S. B. & D. D. Co | 45.9 | 35.9 | 44.1 | 34.6 |
| 47 Washington | New York S. B. Co | 18.5 | 2.8 | 12.4 | 1.7 |
| 48 West Virginia | Newport News S. B. & D. D. Co | 21.3 | 2.2 | 20.5 | 2.2 |
| 49 South Dakota | New York Navy Yard | 0. | 0. | 0. | 0. |
| 50 Indiana | New York Navy Yard | 0. | 0. | 0. | 0. |
| 51 Montana | Mare Island Navy Yard | 0. | 0. | 0. | 0. |
| 52 North Carolina | Norfolk Navy Yard | 0. | 0. | 0. | 0. |
| *Battle Cruisers* | | | | | |
| 1 Lexington | Fore River S. B. Co | .... | .... | .... | .... |
| 2 Constellation | Newport News S. B. & D. D. Co | .... | .... | .... | .... |
| 3 Saratoga | New York S. B. Co | .... | .... | .... | .... |
| 4 Ranger | Newport News S. B. & D. D. Co | .... | .... | .... | .... |
| 5 Constitution | Phila. Navy Yard | .... | .... | .... | .... |
| 6 | Phila. Navy Yard | .... | .... | .... | .... |
| *Scout Cruisers* | | | | | |
| 4 | Todd D. D. & Const. Co | 26.2 | 2.9 | 25. | 1.6 |
| 5 | Todd D. D. & Const. Co | 24.3 | 2.5 | 22.5 | 1.4 |
| 6 | Todd D. D. & Const. Co | 20.1 | 1. | 18.2 | .9 |
| 7 | Beth. S. B. Co. (Fore River) | 0. | 0. | 0. | 0. |
| 8 | Beth. S. B. Co. (Fore River) | 0. | 0. | 0. | 0. |
| 9 | Wm. Cramp & Sons Co | 10. | .... | 9. | .... |
| 10 | Wm. Cramp & Sons Co | 10. | .... | 9. | .... |
| 11 | Wm. Cramp & Sons Co | 0. | .... | 0. | .... |
| 12 | Wm. Cramp & Sons Co | 0. | .... | 0. | .... |
| 13 | Wm. Cramp & Sons Co | 0. | .... | 0. | .... |
| *Miscellaneous* | | | | | |
| Fuel Ship No. 16 Brazos | Boston Navy Yard | 93.1 | 92.6 | 91. | 90.3 |
| Fuel Ship No. 17 | Boston Navy Yard | 23.8 | 1.5 | 20.2 | .5 |
| Fuel Ship No. 18 | Boston Navy Yard | .2 | .2 | .2 | .2 |
| Gunboat No. 21 Asheville | Charleston Navy Yard | 81.3 | 79.3 | 78.7 | 76.7 |
| Gunboat No. 22 | Charleston Navy Yard | 1.3 | .3 | 0. | 0. |
| Hospital Ship No. 1 | Phila. Navy Yard | 27.4 | 15.8 | 26. | 12.5 |
| Amn. Ship No. 1, Pyro | Puget Sound Navy Yard | 86. | 78. | 80. | 72. |
| Amn. Ship No. 2, Nitro | Puget Sound Navy Yard | 38. | 18. | 32. | 8. |
| Rep. Ship No. 1, Medusa | Puget Sound Navy Yard | .... | .... | .... | .... |

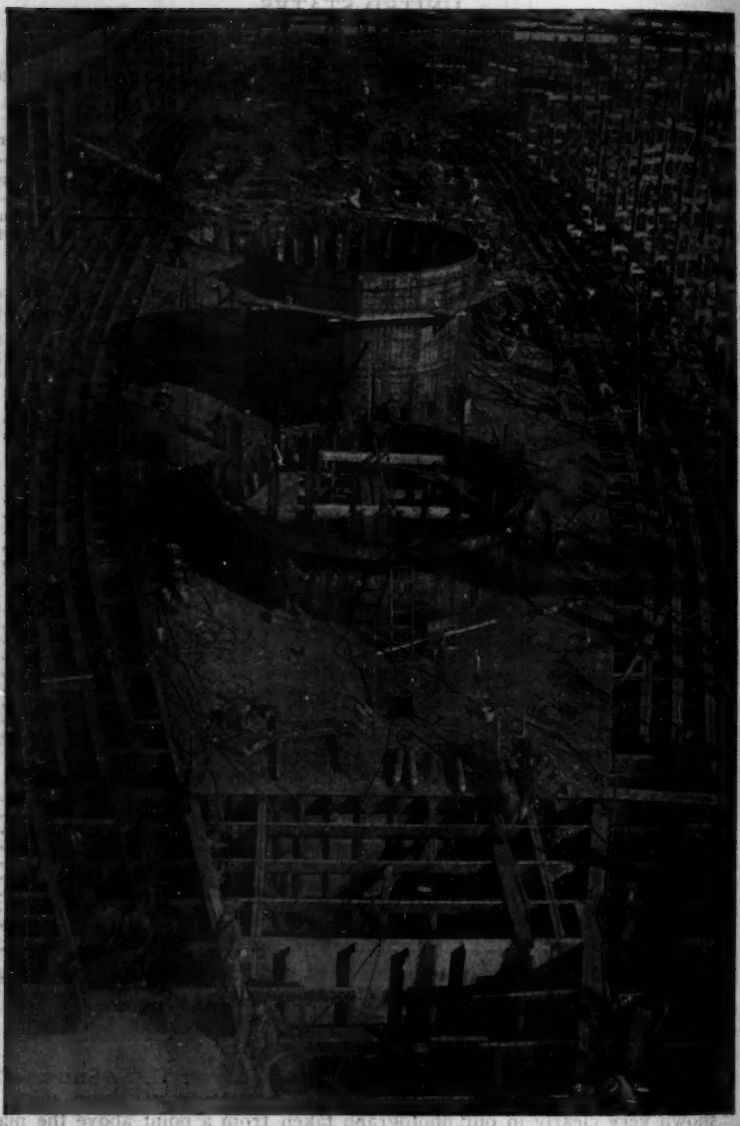
There are 185 destroyers, 69 submarines, 12 oil tankers, 19 sea-going tugs, 31 harbor tugs, and 52 Ford eagles in various stages of completion.

### MATÉRIEL

PROTECTION AGAINST TORPEDOES AND MINES LATEST U. S. SHIPS.—The remarkable character of the underwater protection of these ships is shown very clearly in our photograph taken from a point above the main deck of the *Maryland*, which is now under construction at the Newport News shipyard. It will be seen that, between the outer skin of the ship and the inner wall enclosing the engine and boiler rooms, magazines, etc., there are no less than four longitudinal walls, intersecting the numerous transverse bulkheads and subordinate transverse partitions. Thus, there is provided, a broad belt, 12 to 15 feet in width, of cellular water-tight

Armament ..... 5 18in. T.T. | 4 18in., 1 21in. T.T. | 4 21in. T.T. | 6 18in. T.T. | 8 18in. T.T. | 6 18in. T.T.

From "Naval Construction during War," by Sir Eustace Tennyson D'Eyncourt, K. C. B.; read before Institution of Naval Architects, April 9, 1919.



DECK VIEW OF THE 32,300-TON "MARYLAND" SHOWS THE WIDE ANTI-TORPEDO, CELLULAR CONSTRUCTION, WHICH WILL ENABLE HER TO SURVIVE THE BLOWS OF SEVERAL TORPEDOES.

compartments. The force of the detonation of a torpedo would be expended in rupturing the tough steel of this construction, and its tearing and bursting energy would be so far absorbed that, by the time it reached the inner wall, it would fail to get through. The Germans adopted this construction in their ships to such good effect that when the battle-cruiser *Goeben* was taken over after the armistice, it was found that though she had been torpedoed or mined no less than five times, and although the innermost walls protecting the engine and boiler rooms were bulged inward, they had held. Similarly, although at least four of the German battleships were torpedoed at Jutland, they all succeeded in getting back to port for repairs.—*Scientific American*, 3/5.

## PERSONNEL

REDUCTION OF NAVAL FORCE ORDERED.—The Secretary of the Navy has directed that the total enlisted personnel, regular and reserves, be reduced to 250,000 prior to July 1, 1919; that a material reduction be immediately made in the enlisted personnel now employed on shore, and that in making this reduction personnel relieved from shore duty shall not be released, but shall be sent to sea. Accordingly, the bureau of navigation has issued orders to the commandants of all naval districts to make reductions in their forces and has directed the transfer of certain personnel to the larger receiving ships for detail to sea-going vessels.—*Army and Navy Register*, 5/10.

SHORTAGE OF MEN IN NAVY.—The Bureau of Navigation is confronted with the serious problem of finding enough men to maintain depleted crews for the vessels of the fleet and to meet the constantly increasing demands, with a woeful insufficiency of men wherewith to work. The plan of placing a large number of vessels out of commission was considered, but it is understood that this proposal has not met with favor in the office of operations. Meanwhile the demand for more men is becoming urgent and insistent. When the U. S. fleet arrived in New York there was an immediate call for 7000 regulars, and there were but about 600 to furnish the fleet. Only recently 18 mine sweepers were fitted out for duty in European waters, a duty which is generally recognized as being hazardous and free from romance, and consequently calls for men who are trained in the regular navy and may be expected to remain until the job is finished. Three salvage vessels were also equipped for work which the reservist, no matter how enthusiastic, is not qualified to perform. The Eagle boats are coming apace, the first vessels being assigned immediately to an important detail in European waters.—*Army and Navy Register*, 4/26.

## OPERATIONS

SWEEPING UP AMERICAN MINES.—Eighteen mine sweepers and from 1700 to 1800 men will be employed under Rear Admiral Strauss in sweeping up the 57,000 American mines which were laid in the great North Sea barrage during the war. Two of the craft are now overseas, 12 others are now en route and the last four will sail from Boston. In addition to the sweepers, 20 of the gasoline-driven submarine chasers now in European waters have been assigned as tenders.

The sweepers are powerful seagoing tugs, built for this special duty. They are single-screw, oil-burning craft of about 1000 tons' displacement, and each has a complement of five officers and 75 men. Some of them have already demonstrated their fitness by sweeping up mines planted on the American coast by German submarines. Their steaming radius is such that they can remain at sea many days engaged in this rough and dangerous work.—*Army and Navy Register*, 4/26.

## MERCHANT MARINE

WILL CANCEL SHIP CONTRACTS.—*Shipping Board to Reduce Engagements by 2,000,000 Tons.*—In a statement issued Friday, April 25, Chairman Hurley, of the United States Shipping Board, said:

"Since the signing of the armistice on November 11, 1918, the Shipping Board has cancelled contracts for more than 2,000,000 tons of steel ships.

"In figuring out the balancing of our fleet, we now find it necessary to cancel an additional 2,000,000 tons of steel ships.

"In some of the old and established yards we are now paying from $195 to $225 per ton for cargo steamships and oil tankers. In some of the new and inexperienced yards we are paying as high as $300 per ton for cargo ships.

"As these are war prices and as we feel that we should now be building only on peace prices, we are now considering cancelling all contracts where keels have not actually been laid."—*Official Bulletin*, 5/5.

REPORT AMERICA GETS SEIZED SHIPS.—The retention of the seized German ships by the United States would place at its command permanently such vessels as the *Leviathan*, formerly known as the *Vaterland*. Vessels of this type would be of tremendous service in building up passenger lines on the most efficient basis and by so doing draw freight business.

It was stated in the news dispatch from Paris that the German interests would be credited with a fair price for the tonnage when reckoning was made of the damage done by the German submarines to American tonnage and American interests.

It is considered possible here that the action of the Alien Property Custodian's office in buying the seized North German Lloyd and Hamburg American docks at Hoboken, thus assuring the temporary retention of their control in the government, may have had something to do with a decision at Paris to award the German shipping seized in American ports to the United States.

Here is a list of the former German-owned shipping seized in American ports and which is reported to be involved in the decision made at Paris. The tonnage figures are in relation to the usefulness of the ships as cargo carriers and is reckoned without regard to the passenger service which will be rendered:

| Name | Tonnage | Name | Tonnage |
|---|---|---|---|
| *Actalon* | 7,200 | *Coosa* | 2,485 |
| *Aeolus* | 12,305 | *Covington* | 11,717 |
| *Agamemnon* | 8,700 | *Baron de Kalb* | 8,200 |
| *America* | 20,765 | *Freedom* | 6,800 |
| *Amphion* | 8,950 | *Gen. G. W. Goethals* | 5,437 |
| *Andalusia* | 8,000 | *Gen. H. F. Hodges* | 4,069 |
| *Antigone* | 11,000 | *Gen. O. H. Ernst* | 5,380 |
| *Apelles* | 11,200 | *Gen. W. C. Gorgas* | 5,520 |
| *Arcadia* | 7,100 | *G. Washington* | 13,300 |
| *Argenia* | 7,600 | *Gulfport* | 4,334 |
| *Artemis* | 11,500 | *Honolulu* | 8,000 |
| *Ascutney* | 6,700 | *Houston* | 4,800 |
| *Astoria* | 4,650 | *Huron* | 11,000 |
| *Bath* | 3,978 | *Iosco* | 1,800 |
| *Beaufort* | 2,600 | *Isonomia* | 5,050 |
| *Black Arrow* | 8,000 | *Kittery* | 1,690 |
| *Bridgeport* | 10,000 | *Leviathan* | 15,000 |
| *Camden* | 9,761 | *Long Beach* | 1,967 |
| *Casco* | 7,200 | *Madawaska* | 6,850 |
| *Chattahoochee* | 11,000 | *Mercury* | 10,350 |

| Name | Tonnage |
|---|---|
| *Midget* | 600 |
| *Moccasin* | 4,760 |
| *Monticello* | 12,500 |
| *Montpelier* | 10,000 |
| *Mount Vernon* | 8,300 |
| *Nansemond* | 14,700 |
| *Neuse* | 6,800 |
| *Newport News* | 5,270 |
| *Nipsic* | 2,500 |
| *Nyanza* | 7,750 |
| *Oconee* | 4,200 |
| *Orion* | 5,800 |
| *Osage* | 7,600 |
| *Otsego* | 6,470 |
| *Owasco* | 5,180 |
| *Pawnee* | 6,500 |
| *Pensacola* | 6,040 |
| *Pequot* | 8,879 |
| *Philippines* | 13,000 |
| *Pocahontas* | 10,550 |
| *Powhatan* | 9,510 |
| *President Grant* | 19,810 |
| *President Lincoln* | 21,000 |
| *Princess Matoika* | 10,500 |
| *Quantico* | 2,900 |
| *Quincy* | 5,100 |
| *Quinnebaug* | 2,000 |
| *Rajah* | 3,250 |
| *Rappahannock* | 11,200 |
| *Raritan* | 1,600 |
| *Sachem* | 4,246 |
| *Savannah* | 6,930 |
| *Susquehanna* | 11,650 |
| *Suwanee* | 11,250 |
| *Tacony* | 2,200 |
| *Ticonderoga* | 7,900 |
| *Tippecanoe* | 8,966 |
| *Tunica* | 7,750 |
| *Von Steuben* | 6,000 |
| *Wabash* | 6,775 |
| *Wachusett* | 6,450 |
| *Wacouta* | 3,400 |
| *Wamsutta* | 2,172 |
| *Watauga* | 1,900 |
| *Wyandotte* | 5,900 |
| *Yadkin* | 2,510 |
| *Yazoo* | 2,200 |
| *Yucca* | 4,416 |
| *Yuma* | 2,500 |
| Total, 89 ships | 654,000 |

The names given are those selected by the United States.—*N. Y. Times*, 5/6.

## NAVIGATION AND RADIO

### RADIO TELEPHONY

BATTLESHIP EQUIPMENT.—The possibilities of the wireless telephone in naval maneuvering were quickly recognized by the Navy Department. Commander Hooper, of the Bureau of Steam Engineering, asked us to cooperate in making the wireless telephone a useful piece of equipment in naval service. It was decided to build two experimental sets, install them on battleships and give the operating staff an opportunity to investigate and criticize them from an operating point of view. The construction of two sets was begun in December, 1915, and they were completed about the middle of January. A short description of these sets will not be out of place at this time. Each set consisted of complete transmitting and receiving sets with a motor-generator. The receiving set was built to be set on top of the transmitting set. An extension circuit was provided so as to allow placing the hand set either on the bridge or in the admiral's or captain's cabin so that it would not be necessary for them to go to the radio room to talk. A duplicate hand set was provided for the operator in the radio room, as well as a head telephone for listening-in. The normal condition of the circuit was with the antenna connected to the receiving set. Any call thus coming in would be received. When a call was received and it was desired to talk instead of to listen, a button on the hand set was pressed which caused the relay operated antenna switch to disconnect the antenna from the receiving set and connect it to the transmitting set and at the same time start the transmitting set operating. This operation required only a fraction of a second. It was thus possible to transmit and receive successively on the same antenna by pressing the

button whenever it was desired to talk. The wave length range of the set was 600 to 1200 meters. This system was likewise similar to that at Arlington, but was, of course, quite small and produced only one and one-quarter amperes in the antenna. These sets were installed on the battleships *Arkansas* and *Florida* at Guantanamo, Cuba, the first part of February, 1916. It was found entirely practicable to hold a two-way conversation between vessels over 30 miles apart. There is no reason to think that was the limit of communication, as some of these conversations were overheard in Jamaica, a distance of 175 miles. No attempt was made for range, as that was not the object in building these sets.

*Multiplex Working.*—This experiment pointed out many things in the use of the wireless telephone which it was highly desirable to know. As the result, the Bureau of Steam Engineering approached us later in the same year and requested that a second step be made in the development of a satisfactory set. The fact that this set worked on the same wave lengths as their regular radio telegraph sets, caused considerable interference. It was desired in the telephone field to provide separate possibilities in communication for the navy and not encroach upon the telegraph. It was, therefore, thought desirable to go to much shorter wave lengths and provide a set which would not interfere at all with the telegraphic operation of neighboring vessels and interfere very little with the telegraphic operations on the same vessel on which the telephone was being used. A few field experiments were made with short wave antennas on two ships in July, 1916, to provide data necessary for building these sets and their design and construction was started in October. The new set differed from the old one in that it operated on three wave lengths, 150, 189, and 238 meters, and also in that it was multiplex and allowed nine conversations to be carried on three wave lengths. The basis of the multiplex system which was originated by Mr. R. A. Heising is as follows:

Suppose a wave of 25,000 cycles is modulated according to a speech signal. This wave when received in the receiving set and rectified reproduces the desired speech. If, however, instead of radiating this 25,000-cycle wave directly, we modulate a 150-meter wave with it and radiate the 150-meter wave, on receiving and detecting at the receiving station the 150-meter wave there will be produced the wave of modulation, or the 25,000 cycle wave. This second wave is, therefore, produced in the receiving station not by its direct radiation and reception, but is produced there by being carried by the shorter carrier wave. If it is then selected by tuned circuits and detected, the speech signal becomes audible. Therefore, with these sets provided, it was possible to have three ships transmit simultaneously on the same wave length, 150 meters for instance, one ship using an intermediate frequency of 25,000 cycles, the second an intermediate frequency of 35,000 cycles and the fourth, an intermediate frequency of 45,000 cycles. A receiving station tuned to 150 meters would receive all three double modulated waves. By using a second tuned circuit, one of the stations could pick out any one of these three conversations by tuning the second tuned circuit to 25,000, 35,000 or 45,000 cycles and detecting and would not be interfered with by the other two stations on the same wave length.

These sets were built upon the same plan as the previous ones in that transmitting and receiving sets were built to be placed one upon the other. These sets were installed on the U. S. S. *Pennsylvania, Wyoming* and *Seattle* in January, 1917, but scarcely had they been installed than diplomatic relations with Germany were severed and the assistance in the development of apparatus by the operating staff of the navy was necessarily curtailed.

*Radio Telephone Apparatus for Military Use.*—Beginning with the entry of this country into the war, the demands for radio apparatus for military purposes have resulted in the very rapid commercial development

of this type of equipment. While nothing fundamentally new has resulted from this work, there has been a very practical and valuable result in that the commercial development and manufacture of radio telephone apparatus in general has been put on a basis which otherwise could not have been reached for many years to come.

The first apparatus for war purposes was built at the request of the Navy Department in March, 1917, and consisted of 15 experimental sets which were proposed for use on submarine chasers. These sets were of the continuous wave type and were intended primarily for telegraph communication, but were also equipped with a telephone modulating attachment. The transmitting element employed four tubes of the type used in the transatlantic experiments, and delivered approximately 1.5 amperes into the small antenna of the submarine chaser. In view of the fact that these sets were immediately replaced by an improved type which will be described later, the detailed construction of these sets need not be discussed, and they are mentioned merely to indicate the Navy Department's practical interest in this type of apparatus at a comparatively early date.

*Aircraft Telephony.*—The most prominent and probably most spectacular development of radio telephony during the war was in connection with its use on military aircraft. While radio telegraphy had been used before for fire control and scouting purposes, its field had not gone beyond that of one-way communication, and was confined practically to the use of simple spark gap types of telegraph apparatus.

Anticipating possible employment of radio telephony in this field, the Western Electric Company Engineering organization had done a considerable amount of experimental work in the way of applying the principles demonstrated in connection with earlier experiments in long distance radio telephony to short range work. This work had been carried on for some time under the direction of Mr. H. W. Nichols, and had resulted in the development in experimental form of satisfactory short-range apparatus.

On May 22, 1917, Major General Squire, Chief Signal Officer of the Army, called a conference at Washington to consider the feasibility of intercommunication between airplanes while in flight by means of radio telephony. There were present at this conference besides General Squire, Colonel Rees, of the Royal Flying Corps of Great Britain; Captain, now Colonel, C. C. Culver, of the Signal Corps, and Major, later Lieutenant Colonel, F. B. Jewett, and Captain, later Major, E. B. Craft, who had been assigned from the Western Electric Company Engineering Organization to engage in this work. At this time plans were in the making for the tremendous aircraft program which was later undertaken by the army, and it was clear to all that a successful means of communication between battle planes when flying in squadrons would be of inestimable value and would greatly increase the efficiency with which these squadrons could be maneuvered. The early work had shown such promise that there was justification for assuring the Signal Corps that this means of communication could be worked out successfully and applied to aircraft of various types. As a result of this conference, orders were issued by the Signal Corps for the Western Electric Company to undertake the development of a wireless telephone system for the purpose. The experimental equipment available as a laboratory proposition at this time, served as a basis for the first experimental trials in the air. This transmitting set did not use the Colpitts system of modulation the "constant currents" system of R. A. Heising, which was found to be more compact and easily operated. This system comprises a modulator and an oscillator tube with their plate circuits essentially in parallel for audio frequency currents. They are supplied from a generator through a choke coil whose function is to maintain a practically constant current to the two tubes no matter

how the plate currents may vary individually. A circuit diagram is shown in Fig. 16, and the operation is as follows:

When the transmitter is not actuated there is a certain normal value of voltage impressed upon the grid of the modulator tube, this value being adjusted until the plate current of the modulator is about the same as that of the oscillator. Now the characteristic curve shows that as the grid becomes more negative the plate current decreases at constant plate voltage, and with positive grid voltage it increases. This may be described by saying that the resistance of the plate circuit may be varied by varying the grid voltage, and inspection of the curve shows that this variation may be from a very high value (point $-E$) to a small value for positive grid voltages. In the modulating system of Heising the transmitter voltage acts upon the grid of the modulator and causes the resistance of the plate circuit to vary through a wide range in accordance with the speech voltage. Since this circuit shunts the plate circuit of the oscillator tube (at audio but not at radio frequencies) the oscillator will

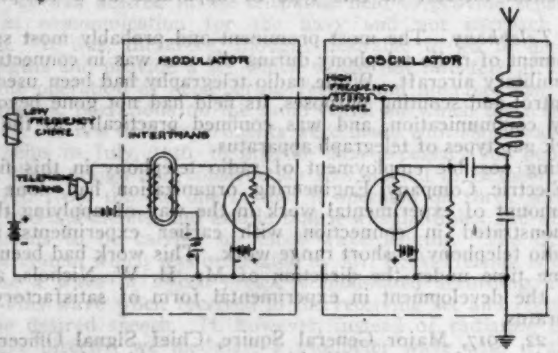



FIG. 16.—SCHEMATIC OF HEISING MODULATION SYSTEM.

be robbed of current or have additional plate current forced through it in accordance with the speech voltage. Its output will thus be varied and it has been found that speech is modulated in this way with very good quality. The efficiency of this system is high and greater than that of an "absorption" system in which power is variably diverted from an oscillating circuit and wasted in a modulating device. In the constant-current system the voltage and current in the oscillator rise periodically to nearly twice their values when the transmitter is not acting, which fact accounts for the increased efficiency.

*Experimental Work.*—This fundamental plan seemed to be the most feasible one to pursue, and on June 5, 1917, another conference was held at Washington to agree upon the various technical features and make plans for carrying out field tests.

It was early realized that the principal difficulty in airplane telephony would be the noises due to the motor and the wind, so that attention was concentrated on the problem of providing against this difficulty both in the transmitting and receiving ends of the combination. Laboratory work was directed particularly toward producing a form of telephone transmitter or microphone which would be as insensitive as possible to these extraneous noises and at the same time be responsive to the voice frequencies. In order that this work might be carried on at high speed, a sound-proof room was constructed and a device provided which reproduced very accurately the noises of the engine exhaust. By the first of

July experiments looked sufficiently promising to warrant tests in the field. On July 2d a complete radio telephone transmitting equipment was taken into the air and speech of good volume and quality was received on the ground, with the transmitting plane two miles away. The development of a suitable receiving head set was carried on simultaneously, and it was found possible to devise a leather helmet with the receiving elements so disposed and screened from external noises that the weak radio signals could be readily observed. On July 4th experimental receiving equipment was taken into the air, and Mr. L. M. Clement, of the Western Electric Company, successfully received speech from the ground at a distance of several miles.

As stated before, the apparatus used in these tests was of an experimental form built in the laboratory. The transmitting set had an output of 0.7 amperes at a wave length range of 200 to 400 meters, the antenna being a trailing wire about 100 meters long.

*Development of Apparatus.*—With the information resulting from these tests, the development of a practical airplane set began at once. During the previous month, comparative tests had been made on a number of proposed modulating systems, with the result that the constant-current system previously described seemed best for the purpose. The problem now was to produce sets of minimum size and weight, physical structures which would withstand the extreme vibrations and jars encountered in flying, especially in landing, the most convenient disposition of control elements, suitable source of power for both high and low voltage, and a form of antenna which would not interfere with the evolutions of a plane in squadron formation.

It was realized that the solution of the last-mentioned problem would consume more time than was at our disposal, and while work was immediately started in the field on antenna measurements and study, the design of the sets proceeded on the basis of using a trailing wire antenna.

The working out of a practical helmet design proved to be more difficult than the success of the earlier experiments indicated. It was found that the degree of interference experienced changed very rapidly with slight imperfections to fit. The problem was also complicated by the necessity of providing means for using oxygen at high altitudes, and of providing for the comfort of the wearer over a period of several hours. It was found that a very slight amount of pressure on certain portions of the ear caused excessive pains and headaches after a very short period, and the final design was a compromise between comfort and efficiency as to sound insulation.

The problem of power supply was an interesting one. It was required that the weight should be reduced to a minimum, which precluded the possibility of employing storage batteries. There are obvious objections, also, to attaching any form of generating device to the propelling engine. Consideration of all the factors led to the adoption of a wind-driven generator for the purpose. This generator of about 100 watts direct current output was required to produce a potential of 300 volts for the plate circuits of the vacuum tubes, and a potential of 25 volts for the filament circuits. It is necessary, to insure most efficient operation, that the filament current be kept constant, and the fact that the specifications called for operation with airplane speeds varying from 40 to 160 miles per hour made the problem of voltage regulation loom large. Ordinary forms of electro-mechanical regulating devices did not prove to be successful, and while it was probable that something of this type would eventually have been developed, the problem was solved by a very ingenious arrangement proposed by Mr. H. M. Stroller, in which the vacuum tube is the essential element. The voltage of the generator is held approximately constant by means of a vacuum tube regulator, which controls the field flux. Two field windings are provided, the main field, which is in series with the

filament of the regulator tube, and a differential field which is in series with the plate circuit. At minimum speed the differential field is inactive and the generator behaves like an ordinary shunt machine, except that the main field has a small resistance in series due to the regulator tube filament. This filament is so designed that the main field current heats it to a temperature which gives a small electron current. This current flows through the differential field and reduces the resultant flux. At minimum speed, the differential current is small, but as the speed increases, the main field current tends to rise (as in any shunt generator) and this increases the temperature of the regulator tube filament. The electron current is, therefore, considerably increased, which current, flowing through the differential field, reduces the generator flux and thus restricts the rise in voltage. Due to the fact that the electron current of the regulator tube increases very rapidly with increase in filament current, the voltage is held practically constant between 4000 and 12,000 rev. per min. The 1.5-ohm resistance units are provided so that the regulator may be set to give different voltages by cutting them in or out of the main field. The 100 ohms shunt resistance is used to prevent hunting.

Upon the completion of the next set of models, field tests were resumed and on August 20th the first two-way telephone conversation between two planes in the air was successfully accomplished. After this first trial, Major Hertholf and Lt. Stevens of the Signal Corps held two-way conversation between planes with very satisfactory results.

At this time two general schemes of control were considered—manual means for transferring from the transmitting to the receiving position, and automatic means for accomplishing the same result through the operation of a remote control relay. It was concluded, because of its simple construction, to employ the manual means of control, the idea being to locate the set in the observer's position in the plane.

On August 22d an informal demonstration of talk from airplane to ground was given for Secretary of War Baker, General Scott, and Colonel Baker. These experiments conclusively demonstrated the practicability of the system and apparatus, and we felt justified in proceeding with its commercial development.

## COMMERCIAL DEVELOPMENT

*Vacuum Tubes.*—While the vacuum tubes that had been developed in the 1915 and 1916 experiments were satisfactory in operation under normal conditions, it was found that the mechanical vibration encountered in the air was such as to necessitate special structures to withstand them. New forms of vacuum tubes, which successfully met these requirements were developed.

The vacuum tubes used in all this work were of the so-called "Wehnelt Cathode" type; that is, the electron-emitting cathode consisting of a metal filament—usually platinum—coated with a mixture of oxides which, when heated to a moderate temperature, give off electrons in great numbers. When properly constructed and treated, such a type has several great advantages:

1. For a given electron emission, the temperature is not so near the point of destruction due to evaporation, etc., as in the case of a pure metal—for instance, tungsten. The result is longer life in operation.
2. For a given change in filament current at working ranges the change in electron emission is smaller in the case of the Wehnelt cathode, permitting of closer regulation in power output.
3. Evaporation of the filament does not go on so rapidly, consequently its electrical behavior is more uniform throughout its life.
4. The electron emission for a given amount of energy supplied to the cathode is larger, resulting in more economical operation of the sets.

It was found that for transmitting and receiving purposes, two types of tube were sufficient. The tube for receiving purposes was designated as VT1 by the Signal Corps and as the CW933 by the navy. A transmitting tube capable of delivering a moderate amount of power—say from 3 to 5 watts high-frequency output—was known as the VT2 by the Signal Corps and as the CW931 by the navy. Vacuum tubes are defined, as far as electrical characteristics in normal operation are concerned, by plate and filament voltages, plate current with normal plate voltage and zero grid voltage, normal filament current, filament life at this current, and by what is known as the amplification constant, which is approximately the ratio, $\mu$, of that change in plate voltage which produces a given change in plate current to the change in grid voltage to produce the same change in plate current.

As indicating some of the problems involved in the commercial production of this entirely new type of equipment, it is interesting to note that prior to August, 1917, the total output of commercial vacuum tubes of this general type was approximately 200 per week, their use being practically confined to long-distance wire telephony and to radio detection purposes. On November 11, 1918, deliveries were being made at the rate of 25,000 per week. This involved the organization of equipment and personnel to do a class of work for which there was practically no experienced talent available and the situation in many features was analogous to that in connection with airplane production.

*Apparatus.*—Tests of the first standardized sets for Signal Corps use were made at Langley Field on October 6. These sets operated very successfully and official demonstrations of two-way communication were made. This set was made up of a combined control panel and receiver with two stages of amplification and a separate transmitting set, the electrical connections being made by flexible cords. By means of the multicontact manual switch located on the control panel, the operator can receive or transmit as desired. The receiver consists of a single tuned circuit of the very simplest type and the amplifier is made adjustable for the convenience of the observer.

While the original requirement was that communication should be maintained at a distance of 2000 yards, all of the tests indicated that successful communication could be obtained at much greater distances. On October 16 an official distance test was made, and communication between planes was maintained at a distance of 23 miles, and from plane to ground, 45 miles. The conditions under which these tests were made were extremely favorable, and are noted merely to show the possibilities of this particular equipment. The figure that was finally established as being representative of what would be required in service was three miles.

A number of sets were immediately constructed, and complete equipment sent overseas with Signal Corps Officers, where they were submitted for the criticism of our military forces.

Several more demonstrations of this apparatus were made, culminating in the official trials at Dayton, Ohio, on December 2, 1917. There were present members of the Aircraft Production Board and the joint Army and Navy Technical Board, and various Signal Corps officers. The demonstration consisted of a three-cornered conversation between two planes in the air and a ground station. At the ground station a loud-speaking receiver was connected to the radio, set in such a way that the entire party of about thirty could overhear the conversation between the fliers and also the speech between the planes and the ground. Under orders transmitted from the ground station, the fliers performed various evolutions in the air, and the observers could see these orders carried out and hear the acknowledgments. In these tests the pilot and observer in each plane were also connected, so that there were five people in constant communication. The maximum distance of the planes from the ground

station was about eight miles, at which distance they were invisible. These tests so conclusively demonstrated the possibilities of the successful use of this apparatus, that quantity orders were immediately placed by the Signal Corps.

The time elements were very short and the problem of adapting the designs to commercial quantity manufacture were many and intricate. This probably is the first instance on record in which the production of radio apparatus, either telephone or telegraph, has been put on a manufacturing basis, in quantities comparable with that obtaining in ordinary lines of electrical manufacture.

The apparatus represents not what would be designed and built under normal conditions with time available for proper study of all the technical features involved, but the best compromise, bringing in such factors as the use of standard parts, available manufacturing facilities and finally the imperative need of haste.

Information from abroad was at times conflicting and inadequate, so that the Signal Corps officers in Washington were often required to render decisions on important points under exceedingly difficult circumstances. We are greatly indebted to Lt. Col. N. H. Slaughter and other officers of the Signal Corps for their effective cooperation in the solution of difficult problems arising from all these causes.

The final standardized form of two-way airplane set is known by the Signal Corps as the SCR-68 set. The elements are so arranged that they can be mounted in the space available in various parts of the machine The main set, however, necessitates being accessible to the operator.

The switch box shown in the center is to provide for communication between pilot and observer by means of the same helmets and microphones as are used for radio communication. This is one of the interesting by-products resulting from the radio development. Heretofore the only practicable means of communication between pilot and observer was by means of manual signals. With the telephone equipment, satisfactory intercommunication could be provided at all times. This has been found very useful in connection with the training of fliers as well as in military operations.

The transmitting and receiving set proper is approximately 17 by 10 by 7 inches in dimensions, and weighs 21 pounds.

The generator is usually mounted in the slip stream of the propeller on one of the struts of the landing gear.

The weight of the complete equipment, including generator and two operators' sets, is approximately 58 pounds.

When receiving only is required, the transmitting portion is omitted, and power is supplied to the filaments by a small storage battery.

Modifications of the SCR-68 sets adapted to different classes of service were developed and manufactured, one of the principal adaptations being a combination transmitting and receiving set for use on the ground. This set was employed principally for training purposes. With this means of communication at hand, the performance of the student could be observed in the air and his faults could be corrected by the instructor on the ground, thus greatly accelerating this training work. Energy for this set was provided by storage batteries, a dynamotor being operated by the storage battery to supply the plate potential.

Up to the time of the signing of the armistice, many thousands of these sets had been manufactured and delivered.

*Short Wave Type.*—Since the first experiments the trailing wire antenna had been employed and wave lengths of from 200 to 500 meters were used. It was realized that a long trailing wire antenna was not well adapted for use on military airplanes for tactical reasons, and it would be very desirable to limit the physical dimensions of the radiating system. This, of course, implies a corresponding reduction in the length of wave radiated

if an efficient system is to be used, and steps were taken to design such a set. There is no difficulty in securing extremely short waves with the vacuum tube oscillator, but there is some difficulty in designing a very compact set, with wave length adjustable over a considerable range and containing amplifiers and modulators, and at the same time avoiding excessive losses. In October, 1917, some laboratory sets were made for wave lengths of the order of 70 to 150 meters, and early in 1918 the Signal Corps requested the development of a short wave set. This was built in April and was electrically essentially the same as the longer wave sets except for minor changes due to the use of higher frequencies of the order of 4,000,000 cycles.

Trials of this system were made at Camp Alfred Vail at wave lengths of 60 meters and above. The antenna first used was a very short structure on the top of the plane with two wires extending to the tail. This antenna had a natural wave length of 32 meters and a resistance of only one ohm. To increase the radiating qualities the rear portion of the antenna was raised and the resistance thereby brought up to nearly three ohms at 75 meters. This structure did not materially increase the head resistance of the plane and did not interfere with its operation. As described later, this form of antenna was soon replaced by another.

The use of short wave lengths brings forward prominently the problem of location of component parts of the set in the plane, for a few unnecessary feet of connecting wire carrying these high frequency currents may cause the failure of the set. For this reason considerable thought was given to the question of location of transmitter and control box.

*Radiating Systems.*—The whole subject of proper radiating systems for use on planes was one to which more time should have been applied than was available at the time of development and manufacture of the first apparatus. A considerable amount of work, however, was carried on and valuable data obtained. This work was started in the summer of 1917 at Langley Field, and was later transferred to Camp Alfred Vail, N. J. The work was in charge of Mr. A. A. Oswald, of the Western Electric Co., under the direction of the Signal Corps, and resulted in the accumulation of a considerable amount of useful data on many types of antenna. There are three important conditions to be met in designing an antenna for use on airplanes.

1. It must be an efficient radiator.
2. It must not be directive.
3. It must not interfere with complicated evolutions of the plane.

The third condition practically prohibits the use of a long trailing wire with a weight, because of the danger of fouling the propeller. This type of antenna is also quite directive.

The details of this antenna investigation should properly be covered in a separate paper. It may be well to state, however, that the best system, all things considered, was found to consist of two short unweighted wires, one from each wing tip. The two wires were joined in parallel above the fuselage, and worked against the conducting portions of the plane as a counterpoise. It was found that the use of one such wire as antenna and the other as counterpoise was not good.

*Ignition Interference.*—Another problem arose when sets began to be installed. This was that of noise in the receiving sets due to the engine ignition, and was very serious in some cases. Its solution was complicated by the fact that it was not allowable to alter the plane equipment in any way, for instance by changing the position of one magneto to secure greater shielding, but it was found that by covering the ignition wires with a flexible conducting tube grounded at intervals this trouble could be practically eliminated.

It was found that in some cases the ignition spark started in the ignition system high-frequency oscillations which were of proper frequency to

affect the receiver. This happened on the submarine chasers, which are driven by gasoline engines, and the trouble was remedied by inserting small iron core choke coils in the ignition leads to change the frequency of the oscillations. It is obvious that the "radio signals" sent out by the ignition spark are many millions of times more intense than those to be received, and it is remarkable that they do not entirely prevent reception. As a matter of fact, successful airplane telegraphy has been carried on in an experimental way, by using the ignition magneto as a radio transmitter.

*Submarine Chaser Equipment.*—During the war important use has been made of the wireless telephone in connection with naval work. Small 110-foot craft had been largely employed in connection with anti-submarine operations. In order to make the most effective use of the various listening devices, and to co-ordinate the operations of the various units, it is very necessary that instantaneous and direct communication be established at all times. Under the direction of the Special Submarine Board of the Navy Department, modified forms of radio telephone equipment were developed for this purpose. Early in November, 1917, the first practical trials were made, and satisfactory operation between chasers approximately five miles apart was obtained. These trials demonstrated the extreme value of this means of communication and sample equipments were immediately dispatched overseas for further trials under actual war conditions.

The circuits of this set are practically the same as the airplane equipment, except that power is obtained from small dynamotors operated from the 30-volt storage batteries with which the chasers are equipped. The set itself was located in the radio room, where it could be attended to by the regular radio operator. A telephone transmitter and receiver is, however, located in the pilot house so that the commanding officer can hold direct conversation with other vessels. The radio operator monitors the conversation and performs all tuning operations, thus leaving the commanding officer free to use the radio telephone as an ordinary wire line, except that he must press a button located at the side of the telephone when talking. The ordinary telephone head set is supplemented by a loud-speaking telephone receiver, which makes it possible for incoming signals to be heard without the use of head gear. To provide sufficient energy for operating the loud-speaking receiver a three-stage amplifier connected to the output side of the radio set is required. It is possible to connect the receiving portion of the radio set to either the ordinary head receiver or to the amplifier with its loud speaker.

This equipment has an effective operating range of about ten miles when used on the 110-foot submarine chasers. One feature not incorporated in the airplane sets consists of a wave length control gear by means of which the set can be operated on any one of five different wave lengths, ranging from 250 to 600 meters. This permits of a certain amount of selective operation within a chaser squadron.

A number of problems were met with in connection with this particular application not the least of which was the suppression of electrical disturbances in the antenna system due to the ignition system of the three propelling engines. Several thousand of these sets have been produced, and practically all submarine chasers sent overseas have been equipped with this apparatus. This apparatus is also being used for short range work on other types of naval vessels, with eminently satisfactory results. Modifications of the airplane type of equipment have also been made for use on naval seaplanes. For some classes of service the demand for longer range work has made necessary the employment of more powerful types of vacuum tubes.

The foregoing covers the most extensive application of vacuum tube radio telephony, the same general type of circuit and apparatus being used for short range telephony and telegraphy on land and water and in

the air. For reasons already mentioned, quantity production has been limited to the earlier models, in spite of the fact that investigations carried on during production have indicated many changes which would improve the electrical and mechanical efficiency of the apparatus.

*The Future of Radio-Telephony.*—The possibility of communication by speech between any two individuals in the civilized world is one of the most desirable ends for which engineering can strive. For this reason it is particularly desirable to form some opinion of the part which radio telephony may play in securing this universal service. It is clear that the elimination of the Morse operator, which is accomplished by the use of radio telephony rather than radio telegraphy, is necessary for universal and direct communication.

Radio telephony and wire telephony offer several sharp contrasts. The latter requires fixed channels of communication whose construction and maintenance necessitates an accessible path between stations, but the results obtained include secrecy, power efficiency, selection of a desired station and freedom from interference. A large item of expense is the line. On the other hand radio telephony requires neither fixed nor accessible channels and no cost at all for line construction and maintenance, but it is non-secret in the practical sense of the word, its power efficiency is low, selection is at present not practicable except in a limited way by wave length, and freedom from interference is not at present an attained fact. Thus while the two systems may be contrasted, they are not comparable, but each is useful in its own field. It is easy to see that radio telephony can never compete with wire telephony in densely populated districts, while wire telephony is a physical impossibility at sea and in the air. Fortunately, however, the connection of a wire system to a radio system is no more complicated than connecting two wire lines by means of a repeater, and, therefore, these two fields, although distinct, are adjacent. Leaving aside for the moment the particular methods by which radio telephone communication is to be carried on, it is clear that the establishment of communication between two given individuals will be most efficiently realized through the use of a combination of wire transmission on a network extending over perhaps 99 per cent of the stations and radio transmission to those relatively few stations to which it is either impossible or impracticable to build lines. These stations will be of two kinds:

1. *Moving,* such as ships, airplanes, trains, trucks.
2. *Fixed but inaccessible,* such as on islands, in deserts and in very sparsely settled regions.

A third class of service is that which is concerned, not with single individuals, but with groups; such service as the broadcasting of news, time and weather signals, and warnings. In some cases one objection to radio telephony would be an advantage in this class of service.

The choice of the particular kind of transmitting apparatus which will ultimately be used in thus extending the range of communication will involve careful consideration of costs and other engineering factors; its feasibility has, however, been conclusively demonstrated.—*Radio Telephony.* By E. B. Craft and E. H. Colpits. (Presented before A. I. E. E.)

NAVY RADIO COMPASS STATIONS.—In addition to the 33 United States Navy radio compass stations already established on the Atlantic and Gulf coasts, the Navy Department has authorized the establishment of 19 such stations on the Pacific coast. These are to be located to cover the entrances of Puget Sound, the Columbia River, Los Angeles, San Diego and San Francisco, which is to be equipped with four stations. The Atlantic coast stations are located at Cross Island, Bar Harbor, Damiscove Island and Appledore Island, Me., Gloucester, Deer Island, Fourth Watch Hill, R. I.; Montauk Point, Fire Island and Rockaway Beach, N. Y.;

Sandy Hook, Mantoloking and Cape May, N. J.; Cape Henlopen and Bethany Beach, Del.; Hog Island, Smith Island and Cape Henry, Va.; Cape Hatteras, Cape Lookout, Cape Fear, North Island, Bull Island and Morris Island, S. C.; St. Augustine and Key West, Fla. The gulf stations are at Burrwood, Pass a Loutre and Grand Island, La.—*Naval Monthly*, May.

The recent developments of wireless telegraphy have required the use of more powerful Hertzian waves than had been sent out by any station up to the time of the war. There are present, therefore, in the ether permeating and surrounding the atmosphere, numerous trains of waves traveling in all directions. It is altogether possible that one of these sets or a set resulting from a combination of several of them should come in contact with a number of conducting bodies so arranged in a casual manner as to form a Hertzian resonator of the required inductance, capacity and resistance to respond to the passing train. There would then be an ether wave excited in the system, a spark would be produced and a fire probably caused as the result of the passage of the wave.

Mr. George A. Le Roy has presented to the Académie des Sciences a note on the possibilities of a fire being produced in this manner. He conducted a laboratory investigation by means of an apparatus which he terms "inflammatory-resonator." It consists of a globular glass flask provided with four openings, two lateral, one at the top and one at the bottom. Through the lateral openings two electrodes are introduced and kept at the desired distance apart by an adjusting mechanism; they constitute the terminals of a Hertzian resonator. The bottom opening permits placing under the electrodes a plate which carries the inflammable substances; there is also at the bottom a connection for exhausting air with a pump, or introducing gases into the globe. Through the top are located the required measuring instruments.

Hertzian waves of relatively low intensity, generated by means of an ordinary Ruhmkorff coil, were sent through the instrument.

Mr. Le Roy asserts that iron electrodes facilitated the inflammation of cotton, amadou, paper, tow, etc. He, therefore, concludes that a condition may be produced in such a case as the piling of a number of cotton bales, when by the breaking of one of the iron bracings an open resonator is virtually formed.—*Mechanical Engineering*, May.

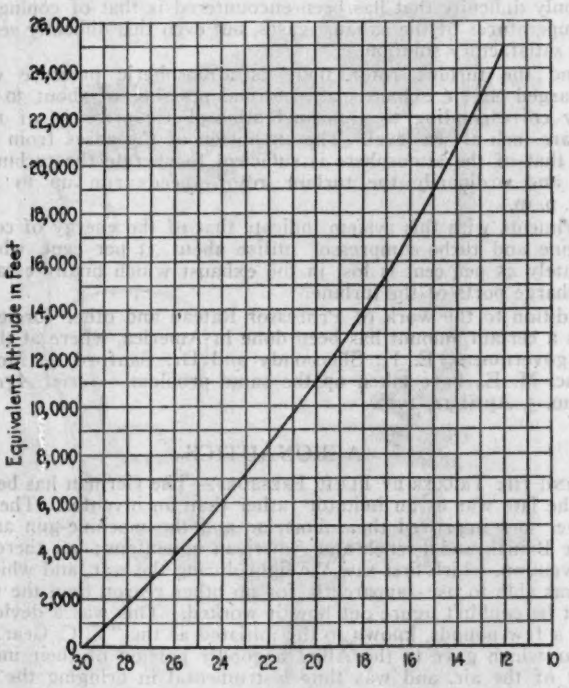
## ENGINEERING

MEANS FOR INCREASING POWER OUTPUT OF AIRCRAFT ENGINES AT HIGH ALTITUDES.—*Maintaining Constant Pressure Between the Carburetors of Air Engines Regardless of the Altitude.*—Leslie V. Spencer.—It is well known that at high altitudes the power developed by the ordinary internal-combustion engine decreases materially because of the decrease of the oxygen content in the cylinder charge. The Bureau of Standards curve between the pressure and altitude at a temperature of 50° F. illustrates this fact very well. From it, it appears that at 20,000 feet an engine operates with an intake pressure of approximately half that at ground level, which affects both the proportion of the mixture and the fuel delivery through the nozzle.

In order to overcome this difficulty in the operation, engineers have turned to the idea of supercompressing the air sent to the carburetor so as to maintain as nearly as possible the ground-level pressure regardless of the height. Such supercompression has been given various names, of which the present writer recommends the term "supercharging." The function of a supercharging device is, however, not to increase the normal ground-level power up to the limit in altitude for which the supercharger is designed.

In Europe the method apparently most widely used is the turbo-super-compression, a good example of which is represented by the Rateau scheme developed by Professor Rateau in France.

The rotary compressor has been tried in competition with the centrifugal type of compressor by the British at the Royal Aircraft Establishment and has been discarded in favor of the latter. The centrifugal form of compressor, however, has proved the most desirable through having a minimum of working parts, being very compact for a given capacity and being capable of operating satisfactorily at top speed over long periods of time.




Bureau of Standards Curve between Pressure and Altitude at Temperature of 50° F.

As to the methods of driving the compressor, there are three possibilities. It can be direct-connected with the engine just as a magneto, possibly with a gear train to step up the speed of the compressor rotor.

Also the compressor might be driven by a small steam turbine, the steam being produced by the exhaust-gas heat. The third alternative is to drive the compressor impeller by means of an exhaust-gas turbine receiving its energy directly from the engine exhaust gas.

In England and Italy direct-connected means of drive through an intermediate gear train have been tried, but great difficulty was experienced in coping with the severe stresses developed in the rapidly operating mechanism due to sudden fluctuations in the speed of the engine.

Steam-turbine drive has not been seriously considered because of the obvious complications and it is the exhaust-gas drive that has found the best favor. The exhaust-gas turbine can be connected directly with the exhaust ports of the engine through special manifolds replacing the standard manifolds, so that all the exhaust must pass through the turbine nozzles and give up its energy to the turbine rotor before being allowed to escape into the atmosphere through the turbine discharge passages.

In the designs which have been experimented with thus far, the turbine rotor and the impeller of the centrifugal compressor are mounted on the same shaft so that the two are in one unit.

The only difficulty that has been encountered is that of coping with the high temperatures of the exhaust gases, but even this difficulty seems to be close to satisfactory solution.

Around the turbine rotor there is atmospheric pressure while the supercharged engine exhausts at a normal pressure of about 30 inches of mercury corresponding to a normal atmospheric pressure of 15 pounds per square inch at sea level. The expansion of the gases from this pressure to that of the atmosphere is sufficient to operate the turbine at high speeds, and ordinarily the turbine rotor speeds run up to 25,000 or 30,000 r. p. m.

Experiments with this system indicate that of the energy of combustion the engine and turbo-compressor utilize about 33 per cent, whereas approximately 45 per cent is lost in the exhaust which finally escapes from the discharge ports of the turbine.

In addition to the work of Professor Rateau and other foreign experimenters a certain amount has been done in America, where at the request of the government, E. H. Sherbondy and Dr. Sanford A. Moss, Mem. Am. Soc. M. E., have taken up the same problem.—*Aerial Age Weekly*, vol. 9, no. 5, April 14, 1919.

## AERONAUTICS

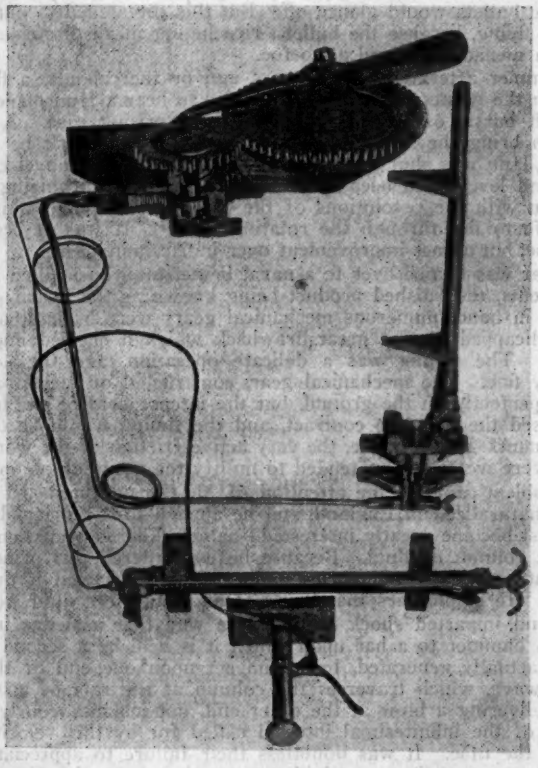
PULLING THE TRIGGER BY FLUID PRESSURE.—The German has been shown up by the late war as an imitator rather than an inventor. The Germans took over and improved the submarine and the machine-gun and a host of other British and French and American inventions; but there was one little invention, which first saw the light during the war, and which Fritzie never was able to use—apparently for no other reason than the very good one that he couldn't figure out how it worked. This was a device, weighing but a few pounds, known to the initiated as the "C. C. Gear." It was this gear which gave to the Allies a goodly portion of their indisputable mastery of the air, and was thus instrumental in bringing the war to a more speedy close.

This device is far from being a complicated one. It contains no intricate mechanism, operating merely by pressing a button or lever. Yet it successfully defied solution by every noted scientist of Germany and Austria for a period of two years during which samples of it were continually falling into Boche hands on captured planes.

The term "gear" as used by pilots of the air signifies a mechanical device by means of which a machine-gun may be timed to fire between the fast revolving blades of a propeller. There are more than a few of such devices; the one most used at the time when the idea first gained acceptance was illustrated in these columns a couple of years ago; but the C. C. gear differs from all the rest in the fact that it is non-mechanical. The tremendous advantage of this will be realized when it is remembered that the terrific speed at which it must operate necessitates the timing of the gear to fire accurately 700 shots a minute through a two- or four-bladed propeller revolving 2000 times a minute.

The history of the gear is romantic in the extreme. When the war started in 1914 no one beyond the novelists of perfervid imagination had any idea that aerial combat would develop to any great extent. The first pilots were chivalrous fellows. A Hun flier darting past a British or French machine would wave his hand genially, and receive a cheery salutation in return. Airplanes were solely for reconnaissance purposes.

Then, one day, a Hun, with villainous intent, pulled out a revolver and took a pot shot at a Britisher. The Englishman was surprised; he hadn't



THE GEAR FOR SHOOTING BETWEEN THE BLADES OF THE PROPELLER BY MEANS OF FLUID PRESSURE, SHOWING ALL THE WORKING PARTS.

thought of that. From that time the war in the air was on; revolver duels became common enough. No one was ever hit, but it was good sport. Even when a British pilot endeavored to make the game a bit more exciting by taking a shotgun aloft with him, and when the Huns retaliated, these weapons were found to be little more dangerous than their predecessors—though it is on record that one enemy machine was thus brought down.

Eventually a pilot, more daring than the rest, conceived the idea of using a machine gun. The Lewis, being light and exceedingly mobile, was the first choice. It was a great improvement, and all parties concerned

recognized it as such from the first. Planes began to carry machine guns as a matter of course; and the only drawback was the limited area in which the gun could be fired—only at right angles to the direction in which the machine was flying, in the majority of instances.

One day a pilot took a chance and fired straight ahead through the propeller. It was a risky proposition; but on landing it was found that comparatively few of the shots had hit the blade—about 4 per cent to be exact. It was, however, expensive as well as dangerous, with propellers costing $100 and more. So the next step was to armor-plate the blades so that the bullets would glance off. But this threatened to put a stop to formation flying, because the bullets, ricocheting in all directions, were as much of a menace to friend as to foe.

One summer afternoon, three years ago or thereabouts, a flight commander on the western front was surprised to hear a Hun plane overhead rattling off bursts of 40 or 50 shots with surprising ease. A pilot was sent up to bring the stranger in, and by great good luck he succeeded. When the Hun was shot down it was discovered that a novel contrivance of rods and levers had been fitted to the engine synchronizing the firing of the gun with the revolutions of the propeller, thereby making it altogether safe to fire through the rotating blades. It was at best a crude contrivance, but a vast improvement over indiscriminate fire.

This gear was turned over to a naval lieutenant who made a number of improvements, the finished product being known as the Scarff gear. The idea once in hand, numerous mechanical gears were brought out, but all were handicapped by one great drawback which it seemed impossible to overcome. The timing was a delicate operation, and the adjustments necessarily fine. The mechanical gear, constructed of metal parts, could be timed perfectly on the ground, but the intense cold of the higher altitudes caused the metal to contract, and the timing would be thrown out of adjustment. Furthermore, the very active friction of the working parts caused severe wear, and so tended to nullify the accuracy of operation.

The problem came to the attention of M. Constantinesco, a Rumanian by birth, naturalized in England, and he applied to it a principle in which he had just become greatly interested—namely, the transmission of power through a column of fluid. Because he encountered this principle while experimenting with sound waves under water, he named it the "sonic" principle. He emphasizes that it is not as though the fluid were a rigid column, and imparted shock in the same way that a sledge imparts the blow of a hammer to a bar upon which it is held by a second workman. There is actually generated, by an impact upon one end of the column, pressure wave, which traverses the column at the rate of 4900 feet per second, delivering a blow at the other end, not instantaneously, but after the lapse of the infinitesimal interval called for by this velocity and the length of the tube. It was doubtless their failure to appreciate that the outfit did not constitute a rigid system that kept the Germans from learning how to operate it—for its advantages are so marked that had they been able to unravel the secret, they would surely have used it.

M. Constantinesco's apparatus consists essentially, as our drawing shows, of a copper pipe filled with oil, at one end of which is a piston and at the other a pushrod to operate the trigger. The piston is connected with the propeller shaft by a gear and a cam. At the proper instant in each rotation of the propeller, the hump on the cam drives the piston down upon the end of the oil column, which is under a pressure of 150 pounds. Through this compressed column the shock of the piston blow travels as a pressure wave; and when it reaches the other end it operates the firing mechanism. The rotation of the propeller generates 40 to 60 of these wave impulses per second, with no friction except the very slight amount to be found between the gear and the cam.

It is, of course, not desired that the gun begin firing the moment the pilot takes the air, and continue until he makes his landing and stops his engine. So some means of control must be provided, and this is made possible by the necessity of having the oil column under pressure before it will transmit an effective blow. A small chamber is provided, connected with the copper pipe, and normally the oil occupies partly this chamber and partly the pipe. When it is desired to set the gun going, the pilot throws a small lever connected with his joy-stick, and this, with the aid of the spring shown in the reservoir, expels the oil from the reservoir, forces it out into the pipe, and puts it under pressure there. Then things begin to happen in the oil column, and the gun begins to speak.—*Scientific American*, 5/17.

DESCRIPTION OF "C-5."—The *C-5* is a twin-engine non-rigid airship of the *C* class, powered with two 125-horse-power union engines. Envelope No. E 106, manufactured by the Goodyear Tire and Rubber Company, Akron, Ohio; car No. A 4126, manufactured by the Burgess Company, Marblehead, Mass. The specifications follow:

Envelope displacement, approximately 178,000 cubic feet.
Envelope length, 192 feet.
Envelope diameter, 41 feet, 9 inches.
Normal speed, 50 miles per hour.
Endurance at normal speed, 10 hours.
Useful load, 4000 pounds.
Crew, six men.
Maximum attainable height, 8600 feet.
Car length, 400.
Fuel consumption approximately ten gallons per hour, at a speed of 42 miles per hour.—*N. Y. Times*, 5/13.

PROMOTING AERIAL NAVIGATION.—A comprehensive program to establish air terminals in at least 32 cities and towns for military, postal and commercial purposes outlined by Major General Charles T. Menoher, director of the air service of the United States Army, to representatives of many states and municipalities at the Southern aeronautical congress, Macon, Ga., has been announced as the government's official plan for cooperating with cities wishing to promote aerial navigation.

Simultaneously it was made known that the air service hopes soon to aid in laying out municipal flying fields wherever local conditions seem to warrant it, and where the municipality will bear expenses necessary in procuring personnel and maintaining the field and equipment, exclusive of airplanes.

At the present the army air service, primarily interested in military aviation, and the Postoffice Department, chiefly concerned with extension of aerial mail facilities, are jointly presenting the project to municipalities because the establishment of landing fields throughout the country will benefit the government as well as cities and towns.

The government has adopted the following general policy:

The air service and Postoffice Department will cooperate fully in establishing municipal landing fields.

The air service will select the landing fields in cooperation with municipal representatives.

The establishment of the field will be made in accordance with articles of agreement to be entered into between the United States Government and the municipality.

At present the government can cooperate only in the establishment of municipal flying fields at cities where the Postoffice Department has

established an aerial mail station, and where the air service cross-country routes require immediate stations. A study of the immediate requirements would indicate that the establishment of municipal flying fields will be confined at present to the following cities and towns: Boston, Mass.; New York, N. Y.; Richmond, Va.; Raleigh, N. C.; Columbia, S. C.; Augusta, Ga.; Macon, Ga.; Atlanta, Ga.; Kissimee, Fla.; Mobile, Ala.; New Orleans, La.; Baton Rouge, La.; Beaumont, Texas; Flatonia, Texas; El Paso, Texas; Texarkana, Texas; Columbus, Ohio; Tucson, Ariz.; Phoenix, Ariz.; Yuma, Ariz.; Bakersfield, Calif.; Fresno, Calif.; Buffalo, N. Y.; Syracuse, N. Y.; Albany, N. Y.; Columbus, N. Mex.; Kansas City, Mo.; Oklahoma City, Okla.; Uniontown, Pa.; Daytona, Fla.; Cleveland, Ohio, and Chicago, Ill.—*Army and Navy Register*, 5/10.

DESCRIPTION OF "N-C" SEAPLANES.—Wing span from tip to tip, 126 feet.

Upper wing from tip to tip, 114 feet.

Aileron projections beyond wing tips, 6 feet on either side.

Lower wing span, 94 feet.

Width of wings, 12 feet.

Distance between wings, 14 feet at center and 12 feet at outer tips of lower wing.

Over-all length from front end to the rear end, 68 feet 3½ inches.

Length of hull, 44 feet 9 inches.

Wing area, 2380 square feet.

Weight of flying boat (empty), including wireless installation and all navigating instruments, 15,100 pounds.

Weight full load flying condition, 28,500 pounds.

Percentage of useful load to total load, that is, load not a portion of structure or equipment, 47 per cent.

Weight carried per square foot of wing surface, 12 pounds.

Estimated speed at full load, 79 nautical miles per hour.

Estimated speed at light load, 84 nautical miles per hour.

Horse-power of four liberty engines, 1600 horse-power.

Number of gasoline tanks, nine in hull, one in upper wing above boat hull.

Capacity of gasoline tanks, 200 gallons for each hull tank and 90 gallons for gravity feed tank in upper wing.

Weight of gasoline system, 6 pounds per gallon of gasoline.

Weight of engines, 825 pounds each.

Weight of boat hull (empty), 2650 pounds.

Area of ailerons, 265 square feet.

Area of stabilizers, 267.6 square feet.

Area of elevators, 240.1 square feet.

Area of rudders, 69 square feet.

Displacement of wing pontoons, 1800 pounds each.

Weight of wing tip pontoons, 95-pounds each.

Gasoline pumps are wind driven by small wooden propellers and are in duplicate, an auxiliary hand-operated gasoline pump is provided.

Flying control is of the dual control Deperdussin system with side-by-side seating.

Pilots are in hull just forward of gasoline tanks.

Complete sets of instruments provided for pilots, including one compass for each pilot.

Navigating station is in front end of bott hull. Navigator is provided with chart board, charts, and ordinary navigating instruments, including compass and sextant.

Complete wireless installation, including telegraph and telephone and wireless direction indicator, is provided. System should give a radius of approximately 300 miles while in the air and of 100 to 150 miles while on the water.

Electric current is furnished by electric generator operated by a wind-driven propellor. Current is delivered to storage batteries. In addition to operating wireless set, storage batteries operate complete lighting system for interior of boat and for wing tip and tail lights as well as lights for night landing.

Wireless operator and engineer are located in main after compartment just aft of gasoline tanks. Each is provided with complete instrument board. Each of these operators has a cylindrical upholstered stool with back rest weighing 5 pounds complete, in the interior of which can be stored the small hand tools required for emergency work.

Cruising speed of boats, about 72 miles per hour.

Gasoline consumption at cruising speed, about 650 pounds average per hour.

Total gasoline carried, about 11,400 pounds.

Cruising radius without wind, about 1476 nautical miles.

Lubricating oil capacity, about 900 pounds.

Crew and provisions, about 1000 pounds.

Crew, five men—two pilots, one navigator, one wireless operator, and one engineer.

Main structure is of Western spruce.

Metal wing fittings and structural fittings in general are of crome vanadium steel of an ultimate strength of 150,000 pounds per square inch.

All flying and landing and control wires are of standard woven airplane cord wire.

Wing covering is linen treated with the ordinary airplane fabric dopes.

Gasoline tanks are of aluminum and gasoline piping is partly of aluminum and partly of copper.

Streamlining forms about wing struts are of micarta. Streamlining of flying and landing wires is of rubber covered with rubberized fabric.

Main keels of boat hulls are of oak or of rock elm. Hull structure is in general of spruce. Planking is of spruce or of cedar. Turtle-back covering is of cedar or of cottonwood birch three-ply veneer.

Cowling around engine nacelles is aluminum.

Four liquid fire extinguishers are carried in each boat hull.

Access to any portion of the boat hull by means of wing passages or to any portion of the power plant by means of hatches in the boat hull may be had either while on the water or while in the air.

All control surfaces, such as ailerons, rudders, and elevators, are balanced by a portion of the area forward of the pivoting points in order to relieve the work of the pilots.—*N. Y. Times*, 5/7.

PARACHUTE DEMONSTRATION.—The first public demonstration of "Life preservers of the air" was staged as one of the special features of the Second Pan-American Aeronautical Convention on May 3.

Lieut. Jean Ors, the noted French aeronaut, whose genius is responsible for the newest aerial safety device, ascended in an aeroplane piloted by Eddie Stinson. As the machine attained a speed of 80 miles an hour and an altitude of 500 feet over the heads of the beholders, Lieut. Ors, who occupied the seat directly behind the pilot, stepped over the cowl and leaped into space, releasing the air life preserver, which is a new type of parachute, by the jerk of the main suspending rope as he went over the side.

Stinson and his aeroplane sailed on in the straightaway. Crowds below caught the flash of Lieut. Ors' body as it was catapulted from the machine by the tremendous speed of the aeroplane. In a split second the umbrella-shaped top of the parachute spread out in a white canopy of safety over his head. Twenty-five feet below, suspended by the guide ropes leading down from the fringe of the "umbrella," Lieut. Ors' plummet-like plunge

earthward was halted before he had descended fifty feet. There was no jerk. The wide spread of the parachute slowed up his descent as gradually as if brakes had been eased on slowly.—*Aerial Age Weekly*, 5/12.

## MISCELLANEOUS

NAVY UNIFORM BOARD.—It is again rumored that a board of navy officers soon will be convened to consider questions pertaining to the uniform of the naval service. For one thing, the present uniform regulations have been amended so often that the present edition is something of a patchwork affair, and there is need for a general revision of them and issue in a new edition. Moreover, a number of changes in the attire continue to be urged. Since adoption of the double-breasted open-collared coat, many officers believe that the overcoat should be of corresponding form. Changes in the cap also have been recommended, in order to make it more distinctly naval in character and less like the form of that of the army. As no collar-marks appear on the new coat, there now is no way to distinguish between line warrant officers—boatswains, gunners and machinists—as all wear the star on the sleeve, and there is need for attention to this detail. The requirement does not affect the staff warrant officers, as, under the amended regulations, they wear their respective corps marks on the sleeve.—*Army and Navy Register*, 4/26.

ANALYSIS OF JAPANESE SHIPPING.—The Department of Communications of Japan announces that the Japanese merchant marine to-day consists of 2578 steamers and 12,236 sailing vessels. The majority of the steamers are, however, coasting vessels not exceeding 1000 tons. Ocean-going steamers above 1000 tons number 599, their gross tonnage being 1,830,006 and their registered tonnage 1,154,377. Of this number six are above 10,000 tons and eight between 9000 and 10,000 tons. There is only one ship between 8000 and 9000 tons. There are 123 vessels between 4000 and 8000 tons. The smaller steamers between 1000 and 4000 tons are most numerous, numbering 366. The majority of sailing vessels are between 20 and 500 tons. There are only five ships between 500 and 1000 tons, while the vessels between 1000 and 2000 tons number only two.—*Shipping*, 5/3.

RED CROSS HOME SERVICE FINDS ALLOTTEES FOR BUREAU OF WAR RISK INSURANCE.—The Bureau of War Risk Insurance has asked the Red Cross to assist it in locating 37,226 persons to whom allotment checks have been sent and which were returned to the Bureau because of incorrect address, removal from old address, or similar reasons. Up to May 1, 9204 persons were found through the efforts of Home Service workers.

The local Red Cross Home Service Section has a list of all checks misdirected to addresses in the county of ————. All persons who have not received their allotment checks, and who believe they may be among those missent, are advised to call at or write to the Home Service office, which is located at ————, and which will assist them in securing their money.

## CURRENT NAVAL AND PROFESSIONAL PAPERS

### UNITED STATES

AMERICAN JOURNAL OF INTERNATIONAL LAW. **January.**—The Lack of Uniformity in the Law and Practice of States with Regard to Merchant Vessels, by *Fred K. Nielsen*. Private Property on the High Seas, by *Graham Bower*. Ships in Enemies' Ports as Prizes (editorial), by *C. N.*

*Gregory.* Pleasure and Racing Yachts in Prize Law (editorial), by *C. N. Gregory.* International Participation in Courts-Martial (editorial), by *George Grafton Wilson.* Prisoners of War Agreement between United States and Germany (supplement).

WORLD'S WORK. **May.**—American Admirals at Sea, by *Lieut. Francis T. Hunter,* U. S. N. R. F.

REVIEW OF REVIEWS. America's Aviation Policy, by Rear-Admiral Robert E. Peary.

SCIENTIFIC AMERICAN. **May 3.**—Increasing Visibility through Knowledge of Camouflage, by *Robert G. Sherrett.* Our Latest Dreadnought *Idaho.* **May 10.**—Sound Ranging Devices. What the Weather Man Thinks of Ocean Flying, by *Willis Rey Gregg,* U. S. Weather Bureau.

AERIAL AGE. **May 19.**—*Glenn H. Curtiss* on the Transatlantic Flight. Principles of Aeroplane Construction, by *Captain James Vernon Martin.*

## GREAT BRITAIN

NINETEENTH CENTURY AND AFTER. **April.**—The New Light on Jutland (with diagrams), by *Sir George Aston.*

FORTNIGHTLY REVIEW. **April.**—The Truth about the Battle of Jutland, by *Archibald Hurd.*

UNITED SERVICE MAGAZINE. **April.**—Some Reflections on Submarines, by *Rooinek.* Wanted—A British-American Naval Entente, by *Charles E. T. Stuart-Linton.*

# DIPLOMATIC NOTES

## FROM APRIL 20 TO MAY 20

PREPARED BY

ALLAN WESTCOTT, Associate Professor, U. S. Naval Academy

### PEACE TREATY HANDED TO GERMANY

The German peace delegates arrived in Paris on April 29, and on May 1, in a brief ceremony, exchanged credentials with representatives of the Allied Powers. On May 7, the anniversary of the sinking of the *Lusitania*, the peace treaty was handed to the German plenipotentiaries in the great hall of the Trianon Palace Hotel at Versailles. Six leaders of the German delegation were present, with eight secretaries and interpreters, and they were met by representatives of the 22 states which had declared war on Germany.

Premier Clemenceau in his opening speech stated that all observations made by the German delegation must be in writing, that there would be no oral discussion, and that the limit of time for consideration of the terms would be two weeks (until May 22). This limit was later made May 29.

In his reply, spoken in German, Count Von Brockendorff-Rantzau admitted the defeat and powerlessness of Germany, but denied that she alone was responsible for the war. He referred to "hundreds of thousands of non-combatants who have perished since November 11 by reason of the blockade," and insisted on a peace in accordance with President Wilson's fourteen points.

MAIN TERMS OF PEACE TREATY.—A full official summary of the Peace Treaty was issued on May 7 and appeared in the American press on May 8. The parts relating to the League of Nations are given elsewhere in the Notes. A briefer summary follows:

It is the longest treaty ever drawn. It totals about 80,000 words, is divided into fifteen main sections, and represents the combined product of over a thousand experts working continually through a series of commissions for three and a half months, since January 18. The treaty is printed in parallel pages of English and French, which are recognized as having equal validity. It does not deal with questions affecting Austria, Bulgaria, and Turkey, except in so far as binding Germany to accept any agreement reached with those former allies.

Following the preamble and deposition of powers come the covenant of the League of Nations as the first section of the treaty. The frontiers of Germany in Europe are defined in the second section. European political clauses are given in the third, and extra-European political classes in the fourth. Next are the military, naval, and air terms as the fifth section, fol-

lowed by a section on prisoners of war and military graves, and a seventh on responsibilities. Reparations, financial terms, and economic terms are covered in Sections VIII to X. Then comes the aeronautic section, ports, waterways, and railways section, the labor covenant, the section on guarantees, and the financial clauses.

Germany by the terms of the treaty restores Alsace-Lorraine to France, accepts the internationalization of the Sarre Basin temporarily and of Danzig permanently, agrees to territorial changes toward Belgium and Denmark and in East Prussia, cedes most of Upper Silesia to Poland, and renounces all territorial and political rights outside of Europe, as to her own or her allies' territories, and especially to Morocco, Egypt, Siam, Liberia, and Shantung. She also recognizes the total independence of German Austria, Czechoslovakia, and Poland.

Her army is reduced to 100,000 men, including officers; conscription within her territories is abolished; all forts to fifty kilometers east of the Rhine are razed, and all importation, exportation, and nearly all production of war material stopped. Allied occupation of parts of Germany will continue till reparation is made, but will be reduced at the end of each of three five-year periods if Germany is fulfilling her obligations. Any violation by Germany of the conditions as to the zone 50 kilometers east of the Rhine will be regarded as an act of war.

The German Navy is reduced to six battleships, six light cruisers, and twelve torpedo boats, without submarines, and a personnel of not over 15,000. All other vessels must be surrendered or destroyed. Germany is forbidden to build forts controlling the Baltic, must demolish Heligoland, open the Kiel Canal to all nations, and surrender her 14 submarine cables. She may have no military or naval air forces except 100 unarmed seaplanes until October 1 to detect mines, and may manufacture aviation material for six months.

Germany accepts full responsibility for all damages caused to the allied and associated governments and nationals, agrees specifically to reimburse all civilian damages, beginning with an initial payment of 20,000,000,000 marks (about $5,000,000,000 at pre-war reckoning), subsequent payments to be secured by bonds to be issued at the discretion of the Reparation Commission. Germany is to pay shipping damage on a ton-for-ton basis by cession of a large part of her merchant, coasting, and river fleets, and by new construction; and to devote her economic resources to the rebuilding of the devastated regions.

She agrees to return to the 1914 most-favored nation tariffs, without discrimination of any sort; to allow allied and associated nationals freedom of transit through her territories, and to accept highly detailed provisions as to pre-war debts, unfair competition, internationalization of roads and rivers, and other economic and financial clauses. She also agrees to the trial of the ex-Kaiser by an international high court for a supreme offense against international morality, and of other nationals for violation of the laws and customs of war, Holland to be asked to extradite the former and Germany being responsible for delivering the latter.

Germany is required to deliver manuscripts and prints equivalent in value to those destroyed in the Louvain Library. She must also return works of church art removed from Belgium to Germany.

The League of Nations is accepted by the allied and associated powers as operative, and by Germany, in principle, but without membership. Similarly, an international labor body is brought into being with a permanent office and an annual convention. A great number of international bodies of different kinds and for different purposes are created, some under the League of Nations, some to execute the Peace Treaty; among the former is the Commission to Govern the Sarre Basin till a plebiscite is held, 15 years hence; the High Commissioner of Danzig, which is created

into a free city under the League, and various commissions for plebiscites in Malmedy, Schleswig, and East Prussia. Among those to carry out the Peace Treaty are the Reparations, Military, Naval, Air, Financial, and Economic Commissions, the International High Court and Military Tribunals to Fix Responsibilities, and a series of bodies for the control of international rivers.

Certain problems are left for solution between the allied and associated powers, notably the details of the disposition of the German fleet and cables, the former German colonies, and the values paid in reparation. Certain other problems, such as the laws of the air and the opium, arms, and liquor traffic, are either agreed to in detail or set for early international action.—*N. Y. Times*, 8/5.

GERMANY'S LOST TERRITORY.—It is estimated that the Peace Treaty will deprive Germany of 1,075,607 square miles of territory (47,787 in Europe) and 15,000,000 people (12,041,603 natives in former colonial possessions). A table of territorial losses follows:

| | Square miles |
|---|---|
| **IN EUROPE** | |
| Alsace Lorraine, to be ceded to France | 5,680 |
| Eupen and Malmedy, circles, to Belgium | 382 |
| Parts of Silesia, Posen, and West Prussia, to Poland | 27,683 |
| Danzig internationalized areas | 729 |
| Sarre coal basin, to France | 738 |
| Southeastern third of East Prussia, nationality to be determined by plebiscite | 5,785 |
| Part of Schleswig, nationality to be determined by popular vote, with view to reversion to Denmark | 2,787 |
| Total in Europe, exclusive of Russia | 47,787 |
| **AFRICAN COLONIES AND DEPENDENCIES** | |
| Togo | 33,700 |
| Kamerun | 191,130 |
| Southwest Africa | 322,450 |
| East Africa | 384,100 |
| Total African possessions | 931,460 |
| **COLONY IN ASIA** | |
| Kiau-Chau | 200 |
| **COLONIES IN THE PACIFIC** | |
| Kaiser Wilhelm's Land | 70,000 |
| Bismarck Archipelago | 20,000 |
| Caroline and Pelew Islands | 560 |
| Marianne Islands | 250 |
| Solomon Islands | 4,200 |
| Marshall Islands, &c. | 150 |
| Samoan Island of Savaii | 660 |
| Samoan Island of Upolu | 340 |
| Total Pacific possessions | 96,160 |
| Total foreign dependencies | 1,027,820 |
| Grand total in Europe and colonies | 1,075,607 |

GERMAN NOTES AND PROTESTS.—In the period of two weeks pending action on the Peace Treaty, the German delegates presented a number of long notes and protests. The Allies appointed 13 committees to consider and reply to these proposals, the members, however, including none of the "Council of Four," who turned their attention to the Austrian peace terms. The protests presented by Germany included the following:

(1) Note on *repatriation of prisoners,* submitted May 11, expressing satisfaction that the Allied Powers recognized in principle the repatriation of

GERMANY'S LOST TERRITORY.

German prisoners without delay, and proposing that details be taken up at once by joint commissions.

(2) Note on *international labor legislation,* submitted May 11, proposing a conference at Versailles of representatives of trade unions of all the contracting powers, the proceedings to be based on the proposals of the International Trade Union Conference held at Berne in February. In a reply dated May 14, M. Clemenceau conveyed the opinion of the Allied and Associated Powers to the effect that labor legislation was sufficiently provided for in Part XIII of the Peace Treaty which created an international labor organization, the first session of which would be held in Washington, in October, 1919.

(3) Note on *economic terms,* declaring that 15,000,000 people in Germany were dependent on foreign trade and foreign raw materials, that Germany could not support more than 40,000,000 on her own resources, and that the terms of treaty would mean economic ruin and starvation.

(4) Note on *territorial questions,* admitting the principle of self-determination in certain instances, but objecting to the sacrifice of territory populated by Germans, and particularly against the Sarre Valley arrangement, the transfer of territory to Belgium, and the evacuation of part of Schleswig.

(5) Note on *reparations,* assenting to payment but not because of responsibility for the war.

(6) A note submitting a *German plan for a league of nations,* differing from the Allied plan chiefly in that it provided for the immediate inclusion of all belligerents. This plan was submitted to the Committee on a League of Nations, which found its merits sufficiently paralleled in the plan already incorporated in the Peace Treaty.

OPPOSITION TO TREATY IN GERMANY.—Following the announcement of peace terms, a week of mourning was officially decreed in Germany, the purpose of which was at least in part to lend support to the protests of the German delegates. President Ebert on May 11 declared the treaty a "monstrous document" and that Germany's hopes of America had proved vain. Chancellor Scheidemann in the National Assembly on May 12 pronounced the terms "unacceptable," finding one hundred clauses beginning with "Germany renounces." The Independent Socialists, on the other hand, insisted that the terms should be accepted and peace declared, though their leader, Hugo Haase, refused to form a government to assume responsibility for signing the treaty.

TREATY VALID WHEN THREE ALLIED POWERS RATIFY.—Paris, May 16.—The German peace treaty, it developed to-day, contains a clause, which has not yet been made public, providing that ratification by Germany and three of the principal associated powers will bring the treaty in force between the ratifying parties, enabling the immediate resumption of trade.

It was pointed out in connection with this stipulation that any nation which withheld ratification after three of the principal powers had ratified would be at a disadvantage in a commercial way, from the fact that the ratifying powers would be able to resume trade relations with Germany at once, while the states which delayed would have no such privilege.—*N. Y. Times,* 17/5.

FRENCH TO SUPPLY ARMY OF OCCUPATION.—Paris, May 8.—Neither the United States nor Great Britain will maintain any part of the armies of occupation which by the terms of the treaty will remain on the Rhine for at least 15 years. The occupation of the left bank of the Rhine will be effected by French and Belgian troops, the great majority, of course, being French. These two nations receive practically all of the indemnity for the collection of which allied troops are to be retained on German territory. It was not the wish of Marshal Foch and the French peace delegation that this arrangement be made.

## PROPOSED AMERICAN UNDERSTANDING WITH FRANCE

On May 8 the following official statement was issued at Paris:

"In addition to the securities afforded in the treaty of peace, the President of the United States has pledged himself to propose to the Senate of the United States, and the Prime Minister of Great Britain has pledged himself to propose to the Parliament of Great Britain, an engagement, subject to the approval of the Council of the League of Nations, to come immediately to the assistance of France in case of unprovoked attack by Germany."

It was later reported that this pledge on the part of the President of the United States was embodied in a letter to Premier Clemenceau, and that the proposal would be presented to the Senate in a form suggesting a defensive alliance.

## REVISED LEAGUE OF NATIONS COVENANT HEADS PEACE TREATY

The revised covenant of the League of Nations was adopted at a plenary session of the Peace Conference on April 28 without division and without amendments, and is given first place as Section I in the peace treaty.

The document as it there appears (for original see U. S. NAVAL INSTITUTE PROCEEDINGS, March, 1919) is outlined as follows in the official summary:

SECTION I.—*League of Nations.*—The covenant of the League of Nations constitutes Section I of the peace treaty, which places upon the League many specific, in addition to its general, duties. It may question Germany at any time for a violation of the neutralized zone east of the Rhine as a threat against the world's peace. It will appoint three of the five members of the Sarre Commission, oversee its régime, and carry out the plebiscite. It will appoint the High Commissioner of Danzig, guarantee the independence of the free city, and arrange for treaties between Danzig and Germay and Poland. It will work out the mandatory system to be applied to the former German colonies, and act as a final court in part of the plebiscites of the Belgian-German frontier, and in disputes as to the Kiel Canal, and decide certain of the economic and financial problems. An International Conference on Labor is to be held in October under its direction, and another on the international control of ports, waterways, and railways is foreshadowed.

*Membership.*—The members of the League will be the signatories of the covenant and other states invited to accede who must lodge a declaration of accession without reservation within two months. A new state, dominion, or colony may be admitted, provided its admission is agreed by two-thirds of the assembly. A state may withdraw upon giving two years' notice, if it has fulfilled all its international obligations.

*Secretariat.*—A permanent secretariat will be established at the seat of the League, which will be at Geneva.

*Assembly.*—The Assembly will consist of representatives of the members of the League, and will meet at stated intervals. Voting will be by states. Each member will have one vote and not more than three representatives.

*Council.*—The Council will consist of representatives of the Five Great Allied Powers, together with representatives of four members selected by the Assembly from time to time; it may co-opt additional states and will meet at least once a year. Members not represented will be invited to send

a representative when questions affecting their interests are discussed. Voting will be by states. Each state will have one vote and not more than one representative. A decision taken by the Assembly and Council must be unanimous except in regard to procedure, and in certain cases specified in the covenant and in the treaty, where decisions will be by a majority.

*Armaments.*—The Council will formulate plans for a reduction of armaments for consideration and adoption. These plans will be revised every ten years. Once they are adopted, no member must exceed the armaments fixed without the concurrence of the Council. All members will exchange full information as to armaments and programs, and a permanent commission will advise the Council on military and naval questions.

*Preventing of War.*—Upon any war, or threat of war, the Council will meet to consider what common action shall be taken. Members are pledged to submit matters of dispute to arbitration or inquiry and not to resort to war until three months after the award. Members agree to carry out the arbitral award and not to go to war with any party to the dispute which complies with it. If a member fails to carry out the award, the Council will propose the necessary measures. The Council will formulate plans for the establishment of a permanent court of international justice to determine international disputes or to give advisory opinions. Members who do not submit their case to arbitration must accept the jurisdiction of the Assembly. If the Council, less the parties to the dispute, is unanimously agreed upon the rights of it, the members agree that they will not go to war with any party to the dispute which complies with its recommendations. In this case, a recommendation, by the Assembly, concurred in by all its members represented on the Council and a simple majority of the rest, less the parties to the dispute, will have the force of a unanimous recommendation by the Council. In either case, if the necessary agreement cannot be secured, the members reserve the right to take such [action?] as may be necessary for the maintenance of right and justice. Members resorting to war in disregard of the covenant will immediately be debarred from all intercourse with other members. The Council will in such cases consider what military or naval action can be taken by the League collectively for the protection of the covenants and will afford facilities to members co-operating in this enterprise.

*Validity of Treaties.*—All treaties or international engagements concluded after the institution of the League will be registered with the secretariat and published. The Assembly may from time to time advise members to reconsider treaties which have become inapplicable, or involve danger to peace. The covenant abrogates all obligations between members inconsistent with its terms, but nothing in it shall affect the validity of international engagements such as treaties of arbitration or regional understandings like the Monroe Doctrine for securing the maintenance of peace.

*The Mandatory System.*—The tutelage of nations not yet able to stand by themselves will be intrusted to advanced nations who are best fitted to undertake it. The covenant recognizes three different stages of development requiring different kinds of mandatories:

(*a*) Communities like those belonging to the Turkish Empire, which can be provisionally recognized as independent, subject to advice and assistance for a mandatory in whose selection they would be allowed a voice.

(*b*) Communities like those of Central Africa, to be administered by the mandatory under conditions generally approved by the members of the League, where equal opportunities for trade will be allowed to all members; certain abuses, such as trade in slaves, arms, and liquor will be prohibited, and the construction of military and naval bases and the introduction of compulsory military training will be disallowed.

(*c*) Other communities, such as Southwest Africa and the South Pacific Islands, but administered under the laws of the mandatory as integral por-

tions of its territory. In every case the mandatory will render an annual report, and the degree of its authority will be defined.

*General International Provisions.*—Subject to and in accordance with the provisions of international convention, existing or hereafter to be agreed upon, the members of the League will in general endeavor, through the international organization established by the Labor Convention, to secure and maintain fair conditions of labor for men, women and children in their own countries and other countries, and undertake to secure just treatment of the native inhabitants of territories under their control; they will entrust the League with the general supervision over the execution of agreements for the suppression of traffic in women and children, &c.; and the control of the trade in arms and ammunition with countries in which control is necessary; they will make provision for freedom of communication and transit and equitable treatment for commerce of all members of the League, with special reference to the necessities of regions devastated during the war; and they will endeavor to take steps for international prevention and control of disease. International bureaus and commissions already established will be placed under the League, as well as those to be established in the future.

*Amendments to the Covenant.*—Amendments to the covenant will take effect when ratified by the Council and by a majority of the Assembly.

PRELIMINARY ORGANIZATION OF LEAGUE.—The Organization Committee of the League of Nations met in Paris on May 5. M. Pichon, French Foreign Minister, was elected chairman, and Sir Eric Drummond of Great Britain assumed his duties as Acting Secretary General. Representatives of Belgium, Greece, Spain, and Brazil were present, in addition to those of the five chief nations of the Entente.

MANDATORIES NAMED FOR GERMAN COLONIES.—An official communication on May 7 gave the following account of action taken regarding the German colonies:

"The Council of Three—M. Clemenceau, President Wilson and Mr. Lloyd George—yesterday decided as to the disposition of the former German colonies as follows:

"Togoland and Kamerun.—France and Great Britain shall make a joint recommendation to the League of Nations as to their future.

"German East Africa.—The mandate shall be held by Great Britain.

"German Southwest Africa.—The mandate shall be held by the Union of South Africa.

"The German Samoan Islands.—The mandate shall be held by New Zealand.

"The other German Pacific possessions south of the equator, excluding the German Samoan Islands and Nauru.—The mandate shall be held by Australia.

"Mauru (Pleasant Island).—The mandate shall be given to the British Empire.

"The German Pacific islands north of the equator.—The mandate shall be held by Japan."

## FIUME QUESTION STILL A DEADLOCK

On April 23, following repeated and vain efforts of the Council of Four to settle Italy's Adriatic claims, President Wilson issued a public statement setting forth his opposition to the cession of Fiume to Italy. In this state-

ment the President showed: (1) that the situation at the time of the secret treaty of London had been completely altered by the entry of new belligerents, the break-up of the Austro-Hungarian Empire, and the armistice terms based on common acceptance of "principles which set up a new order of right and justice"; (2) that if those principles are adhered to, Fiume must serve as an outlet of commerce for the lands to the north and northeast; (3) that Italy no longer is in urgent need of naval protection against Austria-Hungary; and (4) that the concessions offered Italy complete her unity and create no cause for future trouble.

ITALIAN DELEGATES QUIT CONFERENCE.—President Wilson's statement was published with the knowledge of Premiers Lloyd George and Clemenceau, who, while they issued no public statements, supported the position taken by the President. Following the publication, the leaders of the Italian delegation, including Premier Orlando and Foreign Minister Sonnino, returned to Italy on April 24. Italian sentiment, which had been stirred to patriotic fervor, gave enthusiastic support to the position taken by the Italian delegates, to such an extent as to make difficult any change of ground. Justifying his withdrawal, Premier Orlando on April 24 issued a long statement declaring that President Wilson had addressed his appeal directly to the Italian people, in contravention of diplomatic usage.

RETURN OF ITALIAN DELEGATES.—In spite of their apparently resolute opposition to any compromise of the Fiume dispute, the Italian leaders returned to Paris on May 7, in time for the presentation of the treaty. They returned at the invitation of the French and British Premiers, who extended it on the ground that Italy was a special ally of their governments through the London agreement.

On May 12 Premier Orlando said, "There is no change in the situation. Both we and the Americans are now established on the lines of last resistance. It is absolutely a deadlock." In the meantime Fiume was occupied by 24,000 Italian troops, and the Fiume council had voted for annexation to Italy.

## PEACE NEGOTIATIONS WITH AUSTRIA

The Austrian peace delegation arrived at St. Germain-en-Laye, a suburb of Paris where the negotiations with Austria are to take place, on May 14, and exchanged greetings with representatives of the Allied Powers with apparently more cordiality than was shown upon the arrival of the German delegates. The Austrian plenipotentiaries included Karl Renner, Chancellor of the Austrian Republic, Dr. Franz Klein, Peter Eichoff, and Dr. Richard Schuler, with a suite of some sixty members. The exchange of credentials was scheduled for May 21 and the presentation of the Austrian terms for June 2. With regard to boundary settlements on the Italian frontier these terms followed in general the arrangements made in London in 1915 between Italy and the Entente.

An invitation to send delegates to Paris was extended to the Soviet government of Hungary, which however did not accept. The powers negotiating with Austria include only those who declared war upon or broke diplomatic relations with Austria-Hungary.

## GERMANY

RED RULE IN MUNICH OVERTHROWN.—The overthrow of the Soviet rule in Munich was finally accomplished on May 1 by forces of the Hoffmann government assisted by troops supplied by the German Republic. About 150 were killed in the fighting, and 5000 arrests were made later, but many of the Soviet leaders, including Dr. Levien, escaped.

## RUSSIA

KOLCHAK PLANS ADVANCE ON MOSCOW.—According to an interview with Admiral Kolchak published in the *Petit Parisien* of May 13, the All-Russian Government at Omsk is planning a move on Moscow during the coming summer, together with the destruction of the Soviet army. Aid from the Allies was requested in the form of supplies, and a more stringent blockade of Soviet Russia. The Admiral renewed his assurance that the National Assembly would be given control upon final victory.

In the meantime the plan to send supplies of food to Russia by means of a neutral commission has been blocked by the refusal of the Lenine Government to accept the terms accompanying the offer.

FINLAND GOVERNMENT RECOGNIZED.—On May 5 the Council of Foreign Ministers at Paris decided to extend recognition to the *de facto* government of Finland under certain conditions which were not disclosed. Recognition by Great Britain and the United States was officially announced on May 6. Subsequent reports gave information of the advance of a Finnish army towards Petrograd, under the leadership of General Mannerheim, and of a warning to residents of Petrograd issued by the Soviet Government.

## FAR EAST

JAPAN RECEIVES CONCESSIONS IN SHANTUNG.—According to the terms of the Peace Treaty, Germany is required to renounce her share of the Boxer indemnity and all her property in the German concessions of Tientsin and Hankow. The summary of the treaty terms relating to Shantung reads:

"Germany cedes to Japan all rights, titles, and privileges, notably as to Kiao-Chau, and the railroads, mines, and cables acquired by her treaty with China of March 6, 1897, by and other agreements as to Shantung. All German rights to the railroad from Tsing-tao to Tsinan-fu, including all facilities and mining rights and rights of exploitation, pass equally to Japan, and the cables from Tsing-tao to Shanghai and Che-foo, the cables free of all charges. All German State property, movable and immovable, in Kiao-Chau is acquired by Japan free of all charges."

SOVEREIGNTY RESTORED TO CHINA.—In a statement issued on May 5, Baron Makino, head of the Japanese delegation at the Peace Conference,

declared that Japan had agreed to return full sovereignty to China, retaining only the economic privileges granted Germany and the right to establish a settlement under the usual conditions at Tsing-tao. The railway in the province, which is to become a joint Chino-Japanese undertaking, would be guarded by Japanese police forces only to the extent necessary for security of traffic.

The Chinese delegates at the Peace Conference took the ground that by China's entry into the war, all special agreements made with Japan were canceled, and an entirely new settlement of the question should be attempted. This attitude was supported by the Chinese Parliament, which on April 30 passed a resolution directing the Foreign Office to protest against the proposed transfer to Japan.

It is pointed out by Japan that Germany was driven out of Kiao-Chau almost entirely by Japanese forces, while China was still a neutral, and hindered by protests; and that the proposed settlement is in accordance with Japan's secret agreement with the Allied Powers made in February, 1917.

NEW CONSORTIUM FOR CHINESE LOAN.—A new consortium "for undertaking joint financial, administrative, and industrial loans to the Chinese Government" was organized at Paris on May 12 by American, French, British, and Japanese bankers, Mr. Thomas W. Lamont, of J. P. Morgan & Co., presiding. The meeting was called at the instance of the United States, and is said to have resulted from a proposal of Japan to advance $15,000,000 to China secured by a first lien on the Chinese Government's tobacco monopoly. The amount of the forthcoming loan is put at $100,000,000, in four equal annual installments.

Washington, May 12.—The announcement in Paris to-day of the formation of a new consortium for loaning money to China was confirmed officially here. The old consortium will expire on June 18. Four American banks were originally included in it, but they withdrew because of the adverse policy of the State Department under William J. Bryan. Germany was excluded from the existing consortium by the war. Russia's collapse took that country out, and the strain of the war caused Belgium to retire. Japan was never a member of it.

In the new consortium, 37 American banks will participate, following President Wilson's idea of a more democratic arrangement, whereby a larger number of each country's financial institutions may be represented than was the case with the expiring consortium.

American participation in the consortium results from a new policy adopted by the United States Government with respect to Chinese loans, which in effect is that, if the terms of the loan are just and the conditions fair, the government of the United States will assure the American banks participating, after the matter shall have been submitted to the State Department, that the United States will protect the interests secured in good faith.—*N. Y. Times*, 13/5.

# REVIEW OF BOOKS

ON

## SUBJECTS OF PROFESSIONAL INTEREST

"The Naval Architects' and Shipbuilders' Pocket Book." By Clement Mackrow and Lloyd Woodard. Twelfth Edition. 741 pages. (New York: The Norman W. Hanley Publishing Company.)

This is the 12th edition of Mackrow's "Naval Architect and Shipbuilders' Pocket Book," bearing the date of August 1, 1919. An extensive revision of the pocket book was made for the 11th edition, which appeared in January, 1916. Most of the work on the 11th edition was done by Mr. Mackrow himself who, however, died before its completion. It remained to Mr. Lloyd Woolard of the Royal Corps of Naval Constructors to complete Mr. Mackrow's unfinished work. The pocket book contains the usual treatment of the mathematics of engineering common to all handbooks, with such additional mathematics and tables as are specially applicable to naval construction. A chapter is also devoted to aeronautics. It is, perhaps, at first sight not obvious why a handbook on naval architecture should concern itself with the science of aeronautics. The inclusion of this subject is however logical, because the mathematics of stability, displacement, strength calculations, etc., are the same for aircraft as for ships, particularly for the lighter-than-air types of aircraft.

In an appendix to the 12th edition a number of pages are devoted to estimating the cost and weight of merchant vessels. While estimating the weight of structural steel has been covered in some detail, the article is hardly of much help in estimating costs. Reliable and usable data for estimating the cost of ship construction are still a conspicuous omission from handbooks and other treatises on naval construction. Data as to the cost per ton of building vessels in the past are of little use to the estimating department of a shipyard. Something more fundamental is needed. It should be possible to compile data giving the man hours required per ton, or other unit, to produce the various parts entering into the building of a ship. The man-hour unit eliminates fluctuations in wages and differences in local conditions. There will be a great demand for any book which treats the subject of cost estimating on this basis and it is hoped that some one will fill this long-felt need. Unfortunately, those who have the time and are interested in writing are usually not the ones who have access to cost data.

Mackrow's pocket book is more valuable to the British naval architect and draftsman than to the American user, as the data are based principally on British mill and engineering practice.

J. A. F.

"The Grand Fleet, 1914-1916, Its Creation, Development and Work." By Admiral Viscount Jellicoe of Scapa. (Cassell, February, 1919.)

This stout volume of 464 pages of text, with an appendix, 9 plates and 13 diagrams, will be found interesting reading by men equipped with the technical knowledge to appreciate the significance of the information it gives as to the employment of the British Grand Fleet during the greater part of the war; but it has another importance almost equally as great, for it is an historical document of the very first rank, and as such it is here considered.

It is a consecutive narrative in the direct and impartial style of military men, who are trained to deal with facts rather than opinions or sentiments, and its language and tone are those of the official report. It begins with an account of the circumstances under which its author, then Sir John Jellicoe, was selected at the beginning of the war to command the newly constituted Grand Fleet, and it gives a chronological record of the movements of that force, of the conditions under which it operated, and of the ideas and convictions in accordance with which it was directed up to the author's relinquishment of its command in November, 1916.

Historically it is important as the first public revelation of serious deficiencies in British naval equipment at the outbreak of the war. The small number of effective destroyers comes as a surprise, but it has a parallel in the lack of frigates which Lord Nelson felt so bitterly that he said the phrase "lack of frigates" would be found graven on his heart. Modern conditions make the destroyer an even more indispensable type of craft than the frigate was a century ago; so the British paid a heavy price, in the way of greater losses from submarines and greater immunity on the part of the German fleet, for their failure to establish the same superiority in destroyers that they possessed in other classes of ships.

Other ways in which Lord Jellicoe declares the Germans to have had an advantage were: In cruising radius and surface speed of submarines; in fire-directing devices on fighting ships; in thicker and more extensive armor on their larger craft, as a result of better design and the use of small tube boilers which gave greater horsepower for a given weight; in superior range-finding devices; and in a delay-action fuse that ensured the bursting of the shell inside instead of outside of the armor of the ship hit.

These are advantages due to superior technical skill on the part of the Germans, but there were others that arose from the conditions under which the war was fought. The vastly greater responsibilities of the British fleet imposed much more wear and tear on it than on the Germans, who were also in a position to conduct such operations as they chose at times when their power was at its maximum, and who also, from operating near their bases, could carry less fuel, and so gain slightly in speed. Apparently Lord Jellicoe attributes the high angle at which the German shells struck to the long range at which the battle was fought rather than to greater power of elevation in the German guns, and their greater effectiveness on such ships as the *Invincible* and *Queen Mary* would therefore be due to the thinner

armor and lack of magazine protection on those ships more than to superiority in German gun control.

Yet another disadvantage under which the British operated Admiral Jellicoe points out to have been a lack of adequate docks; a deficiency he attributes to the government's indisposition to spend money for these unspectacular but necessary adjuncts; a parsimony which, he says, seriously restricted the design of ships of large displacement, and necessitated the sacrificing of advantages in them that the possession of docks of sufficient capacity would have made possible. He also cites the strike of the Welsh miners as having for a time restricted the movements and threatened the power of the Grand Fleet, and he had to face and overcome a serious lack of harbor defences at the beginning of the war.

All these things in Admiral Jellicoe's book make the German fleet seem to have been a much more formidable and effectively employed force than would be inferred from its abject surrender without a fight; but the historian, although he will assume that Admiral Jellicoe has proved to those equipped to judge that he was proficient as an organizer and thoroughly conscientious and competent in the technique of his profession, will probably be inclined to think that he emphasizes too strongly the inferiority in matériel of the British fleet. There is a very obvious reason for this in the fact that the book, while in no sense contentious, is still written mainly to justify Admiral Jellicoe's record while he was in command of the Grand Fleet, and to demonstrate that the battle of Jutland was a British and not a German success. Undoubtedly the Grand Fleet accomplished much during the first two years of the war. Undoubtedly the results of the battle of Jutland proved it a British victory. Undoubtedly also the British fleet was maneuvered with superior skill during that battle, but, from the point of view of history, it does not appear a brilliant victory, and Admiral Jellicoe's book does not remove the possibility of arguing plausibly that better results might have been obtained in that engagement if the unquestioned British superiority in most respects had been brought to bear with more decision and persistency. The book, in short, does not make it evident that the leadership in the battle of Jutland displayed the "Nelson touch."

S. G.

"Submarine and Anti-Submarine." By Sir Henry Newbolt. 312 pages, frontispiece in color and 20 other illustrations in pen and ink by Norman Wilkinson, R. I. $2.25 net. (New York: Messrs. Longmans, Green & Co.)

This book, while written for general circulation, and untechnical save in the accurate accounts of maneuvers during engagements and the correct use of nautical terms, should prove exceedingly interesting and valuable reading to any one connected with the naval service. The opening chapter is a comparison of the national spirit and ideals of the British and German nations and the second a very complete historical review of the conception and development of the submarine. The remaining chapters are, in the

main, a collection of concise narratives, based on official reports, logs and other authentic sources, covering practically the entire range of British submarine and anti-submarine activities during the present war, together with a chapter discussing the part the submarine played in the war policies of Great Britain and Germany; a chapter on "The Hunted," which contains an account by both sides of the *Fanning-Nicholson vs. U-58* engagement; and, in the closing chapter, an excellent account of the Zeebrugge and Ostend affairs. The illustrations have no particular merit and, considering the character of the binding and the quality of the paper used, the price seems rather high.

L. A.

"Official Aero Blue Book and Directory, 1919." Henry Woodhouse, Editor. (Published by the Century Co., New York, at $5.00)

The handsome volume with the above high-sounding title contains a good deal of information interesting from a purely historical standpoint. In order to command the price at which it is sold, however, it has been padded with propaganda, advertisements (not confined to the advertising pages) and irrelevant pictures.

Although the book was not published until March, 1919, much of the material applies only to conditions existing during the war. In this connection I was interested in the advocacy, on page seven, of the Postal Air Service as a training for bombing aviators on account of the similarity (*sic*) between dropping mail bags and bombs. I hardly think that the postal aeroplanes will be forced to operate at the heights which were found necessary for bombing machines towards the close of the war.

Over 70 pages are devoted to the description in utmost detail of eight "airways," five transcontinental and three coastal, proposed by the Aero Club of America.

A chapter entitled "A Flight Across the Atlantic" is an attempt to anticipate the experiences of an actual crossing. In a foreword the editor has the good grace to state that it is an account of an "hypothetical" flight. When it originally appeared in *Flying* there was no such explanation and some of the London newspapers accepted the account at its face value, which is either a commentary upon the appalling lack of technical knowledge of the "aviation experts" of the journals or a great tribute to the imagination of the writer.

Following are chapters giving the histories of various sporting events beginning with the Gordon Bennett Aviation and Balloon Trophies. As these events were run under the auspices of the Fédération Aéronautique Internationale of which the Aero Club of America is the representative I expected that care would be taken to have the accounts correct if for no other reason than to justify the title of the book. I was disappointed however.

The history of the Gordon Bennett Aviation Trophy contains many errors in spelling and gross inaccuracies in the times. As an example, the time for

Latham, the third to finish, in the 20 kilometer 1909 race is given as 15 minutes 50⅗ seconds which would have tied him with the winner Glenn (not Glen) Curtiss. As a matter of fact, Latham took 17 minutes 32 seconds. Again, the record given for Prévost, the winner of the 1913 cup, is 200 kilometers in 50 minutes 45⅗ seconds. I happened to have witnessed this race, which was held at Rheims, and my records show that he took exactly nine minutes longer than the time stated. Such mistakes as these are really inexcusable in a book pretending to be "official."

In the history of the Gordon Bennett Balloon Trophy, written by Mr. Hawley, the races won by Americans are described in great detail, whereas those won by representatives of other nations are dismissed with a few lines. The 1912 race is referred to in the following quaint manner: ". . . . the seventh race for the cup will have been competed for before this is published (*sic*), and the club members all hope that the good team that is going to Germany to compete will bring the cup back to the Aero Club, as it is sadly missed from the trophy room after two years of possession." That is all.

For the benefit of the reader I should like to state that the 1912 race was won by the French representative Bienaimé.

Let us sincerely hope that if future editions of the book contain articles written in 1912 pains will at least be taken to edit them properly.

The remaining pages contain descriptions of the lesser contests, lists of qualified pilots and a directory of aeronautic organizations. Finally, there are given American and world's aviation records. These are stated to be only to December 31, 1915, but, in an effort to bring the list up to date, the flight of the *NC-1* seaplane with 51 (not 50) people and Captain Schroeder's height record of 28,900 feet are included.

This list contains very few mistakes, but why should there be any? With the exceptions noted above it could have been set up in type three years ago and proofread ever since.

J. J. I.

*"The Hatchet* of the U. S. S. *George Washington."* Compiled by Captain Edwin T. Pollock, U. S. N., and Lieutenant (j. g.) Paul F. Bloomhardt, Chaplain Corps, U. S. N. Net proceeds to Navy Relief Society, Washington, D. C., from which copies may be obtained. Price $2.00.

The daily paper of the *George Washington*, published during nine eastward passages from February 21 to December 12, 1918, may now be had in a collected volume, each number an exact copy, even to printer's errors, of *The Hatchet* as it appeared "on the high seas." The errors, typographical or otherwise, in no way detract from the interest of the series, which, considering the difficulties and distracting responsibilities under which the editor, Chaplain Bloomhardt, and his corps of helpers labored, is a highly creditable journalistic achievement. News and humor mingle—the former in concise radio messages that recall the stirring events of the last year of the war; the latter with occasional effusions, such as the "Letters to Mable" and the "Badger Fight Hoax," which deserve their rescue from oblivion.

It was hardly fair to President Wilson that, when he went across, *The Hatchet* should have suddenly become a demure and humorless sheet.

In the present volume there are full-page photographs of Captains Pollock, Wortman and McCauley, the successive commanders, and lists of officers and men attached and passengers carried—altogether an interesting sample of naval journalism and a record of historical value.

A. W.

NOTICE TO MEMBERS

More members, both regular and associate, are needed. Any increase in membership is highly necessary to maintain a sufficient number to obtain advantageous rates and space in the publication.

Members are urged to bring the attention of eligible persons to this Institute and to have them join at once.

By order of the Board of Control

Secretary and Treasurer, U. S. Naval Institute

Annapolis, Md.

Dear Sir:

Please enroll me as a member (associate member) of the U. S. Naval Institute from this date.

1921

Signature

Address

Rank or Rate

Ship or Station

# NOTICE TO MEMBERS

**More members, both regular and associate, are much desired. Any increase in membership invariably means larger number of papers and essays submitted, and consequently an improvement in the PROCEEDINGS.**

**You are requested to send or give the attached slip to some one eligible for membership, urging him to join.**

**By direction of the Board of Control,**

**G. M. RAVENSCROFT,**
***Secretary-Treasurer.***

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**Attention is invited to extracts from the constitution on the opposite page as to the requirements in making applications for life, regular and associate membership. Members and associate members are liable for the payment of the annual dues until the date of the receipt of their resignation in writing. Annual dues $2.50.**

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.....*191*

*To the Secretary and Treasurer,*
*U. S. Naval Institute,*
*Annapolis, Md.*

*Dear Sir:*

*Please enroll my name as a* { *regular* / *associate* } *member of the U. S. Naval Institute from this date.*

*Very truly yours,*

.....

.....

# NOTICE

The U. S. Naval Institute was established in 1873, having for its object the advancement of professional and scientific knowledge in the Navy. It is now in its forty-sixth year of existence, trusting as heretofore for its support to the officers and friends of the Navy. The members of the Board of Control cordially invite the co-operation and aid of their brother officers and others interested in the Navy, in furtherance of the aims of the Institute, by the contribution of papers and communications upon subjects of interest to the naval profession, as well as by personal support and influence.

On the subject of membership the Constitution reads as follows:

## ARTICLE VII

Sec. 1. The Institute shall consist of regular, life, honorary and associate members.

Sec. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fees to the Secretary and Treasurer. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

Sec. 3. The Prize Essayist of each year shall be a life member without payment of fee.

Sec. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control. To be declared elected, they must receive the affirmative vote of three-quarters of the members represented at regular or stated meetings, either in person or by proxy.

Sec. 5. Associate members shall be elected from Officers of the Army, Revenue Cutter Service, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

Sec. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

Sec. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: "Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control. The Board of Control will at each regular meeting ballot on the nominations submitted for election, and nominees receiving a majority of the votes of the board membership shall be considered elected to membership in the United States Naval Institute."

Sec. 8. The annual dues for regular and associate members shall be two dollars and fifty cents, all of which shall be for a year's subscription to the UNITED STATES NAVAL INSTITUTE PROCEEDINGS, payable upon joining the Institute, and upon the first day of each succeeding January. The fee for life membership shall be forty dollars, but if any regular or associate member has paid his dues for the year in which he wishes to be transferred to life membership, or has paid his dues for any future year or years, the amount so paid shall be deducted from the fee for life membership.

## ARTICLE X

Sec. 2. One copy of the PROCEEDINGS, when published, shall be furnished to each regular and associate member (in return for dues paid), to each life member (in return for life membership fee paid), to honorary members, to each corresponding society of the Institute, and to such libraries and periodicals as may be determined upon by the Board of Control.

The PROCEEDINGS are published monthly; subscription for non-members, $3.00; enlisted men, U. S. Navy, $2.50. Single copies, by purchase, 30 cents; issues preceding January, 1919, 50 cents.

All letters should be addressed U. S. Naval Institute, Annapolis, Md., and all checks, drafts, and money orders should be made payable to the same.

# SPECIAL NOTICE

## NAVAL INSTITUTE PRIZE ESSAY, 1920

A prize of two hundred dollars, with a gold medal, and a life-membership (unless the author is already a life member) in the Institute, is offered by the Naval Institute for the best original essay on any subject pertaining to the naval profession published in the PROCEEDINGS during the current year. The prize will be in addition to the author's compensation paid upon publication of the essay.

On the opposite page are given suggested topics. Essays are not limited to these topics and no additional weight will be given an essay in awarding the prize because it is written on one of these suggested topics over one written on any subject pertaining to the naval profession.

The following rules will govern this competition:

1. All original essays published in the PROCEEDINGS during 1919, which are deemed by the Board of Control to be of sufficient merit, will be passed upon by the Board during the month of January, 1920, and the award for the prize will be made by the Board of Control, voting by ballot.

2. No essay received after November 1 will be available for publication in 1919. Essays received subsequent to November 1, if accepted, will be published as soon as practicable thereafter.

3. If, in the opinion of the Board of Control, the best essay published during 1919 is not of sufficient merit to be awarded the prize, it may receive "Honorable Mention," or such other distinction as the Board may decide.

4. In case one or more essays receive "Honorable Mention," the writers thereof will receive a minimum prize of seventy-five dollars and a life-membership (unless the author is already a life member) in the Institute, the actual amounts of the awards to be decided by the Board of Control in each case.

5. It is requested that all essays be submitted typewritten and in duplicate; essays submitted written in longhand and in single copy will, however, receive equal consideration.

6. In the event of the prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of the gold medal.

By direction of the Board of Control.

G. M. RAVENSCROFT,
*Commander, U. S. N., Secretary and Treasurer.*

## TOPICS FOR ESSAYS

SUGGESTED BY REQUEST OF THE BOARD OF CONTROL

"Duties and Responsibilities of Subordinates with Special Reference to the Relations between Commanders-in-Chief and Chief of Naval Operations; Commanders-in-Chief and Force Commanders; Force Commanders and Division Commanders."

"Initiative of the Subordinate—Its True Meaning."

"Military Efficiency Dependent upon National Discipline."

"Governmental Organization for War."

"Naval Gunnery, Now and of the Future."

"Naval Policies."

"The Place of the Naval Officer in International Affairs."

"Moral Preparedness."

"Tact in Relation to Discipline."

"The Principles of Naval Administration in Support of War-Time Operations."

"Responsibilities and Duties of Naval and Military Officers of the United States in Educating and Informing the Public on Professional Matters."

"A Commission in The Navy: Its Meaning and the Obligations Which It Involves."

"The Relations of an Officer to his Subordinate, Both Commissioned and Enlisted."

"The True Meaning of the Expression 'An Officer and a Gentleman.'"

"Seen in the Light of Recent Events, What Should Be the United States Navy of the Future as Regards Types and Numbers of Ships."

"Probable Future Development of Surface-craft, Air-craft and Submarines and the Relation of these Types to Each Other and to Naval Warfare in General."

"The Grand Strategy of the Great War, with Especial Reference to Coördination, and Lack of Coördination, Between Naval and Military Forces."

"The Problem of Overseas Operations in the Light of Recent Developments."

"The Influence of Sea Power upon History as Illustrated by the Great War."

# LIST OF PRIZE ESSAYS

## "WHAT THE NAVY HAS BEEN THINKING ABOUT"

1879

**Naval Education.** Prize Essay, 1879. By Lieut. Commander A. D. Brown, U. S. N.

NAVAL EDUCATION. First Honorable Mention. By Lieut. Commander C. F. Goodrich, U. S. N.

NAVAL EDUCATION. Second Honorable Mention. By Commander A. T. Mahan, U. S. N.

1880

**"The Naval Policy of the United States."** Prize Essay, 1880. By Lieutenant Charles Belknap, U. S. N.

1881

**The Type of (I) Armored Vessel, (II) Cruiser Best Suited to the Present Needs of the United States.** Prize Essay, 1881. By Lieutenant E. W. Very, U. S. N.

SECOND PRIZE ESSAY, 1881. By Lieutenant Seaton Schroeder, U. S. N.

1882

**Our Merchant Marine: The Causes of Its Decline and the Means to Be Taken for Its Revival.** "Nil clarius aquis." Prize Essay, 1882. By Lieutenant J. D. Kelley, U. S. N.

"MAIS IL FAUT CULTIVER NOTRE JARDIN." Honorable Mention. By Master C. G. Calkins, U. S. N.

"SPERO MELIORA." Honorable Mention. By Lieut. Commander F. E. Chadwick, U. S. N.

"CAUSA LATET: VIS EST NOTISSIMA." Honorable Mention. By Lieutenant R. Wainwright, U. S. N.

1883

**How May the Sphere of Usefulness of Naval Officers Be Extended in Time of Peace with Advantage to the Country and the Naval Service?** "Pour encourager les Autres." Prize Essay, 1883. By Lieutenant Carlos G. Calkins, U. S. N.

"SEMPER PARATUS." First Honorable Mention. By Commander N. H. Farquhar, U. S. N.

"CULIBET IN ARTE SUA CREDENDUM EST." Second Honorable Mention. By Captain A. P. Cooke, U. S. N.

1884

**The Reconstruction and Increase of the Navy.** Prize Essay, 1884. By Ensign W. I. Chambers, U. S. N.

1885

**Inducements for Retaining Trained Seamen in the Navy, and Best System of Rewards for Long and Faithful Service.** Prize Essay, 1885. By Commander N. H. Farquhar, U. S. N.

1886

**What Changes in Organization and Drill Are Necessary to Sail and Fight Effectively Our Warships of Latest Type?** "Scire quod nescias." Prize Essay, 1886. By Lieutenant Carlos G. Calkins, U. S. N.

THE RESULT OF ALL NAVAL ADMINISTRATION AND EFFORTS FINDS ITS EXPRESSION IN GOOD ORGANIZATION AND THOROUGH DRILL ON BOARD OF SUITABLE SHIPS. Honorable Mention. By Ensign W. L. Rodgers, U. S. N.

1887

**The Naval Brigade: Its Organization, Equipment and Tactics.** "In hoc signo vinces." Prize Essay, 1887. By Lieutenant C. T. Hutchins.

1888

**Torpedoes.** Prize Essay, 1888. By Lieut. Commander W. W. Reisinger, U. S. N.

1891

**The Enlistment, Training and Organization of Crews for Our Ships of War.** Prize Essay, 1891. By Ensign A. P. Niblack, U. S. N.

DISPOSITION AND EMPLOYMENT OF THE FLEET: SHIP AND SQUADRON DRILL. Honorable Mention, 1891. By Lieutenant R. C. Smith, U. S. N.

1892

**Torpedo-boats: Their Organization and Conduct.** Prize Essay, 1892. By Wm. Laird Clowes.

1894

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NAVAL REFORM. Honorable Mention, 1894. By Passed Assistant Engineer F. M. Bennett, U. S. N.

1895

**Tactical Problems in Naval Warfare.** Prize Essay, 1895. By Lieut. Commander Richard Wainwright, U. S. N.

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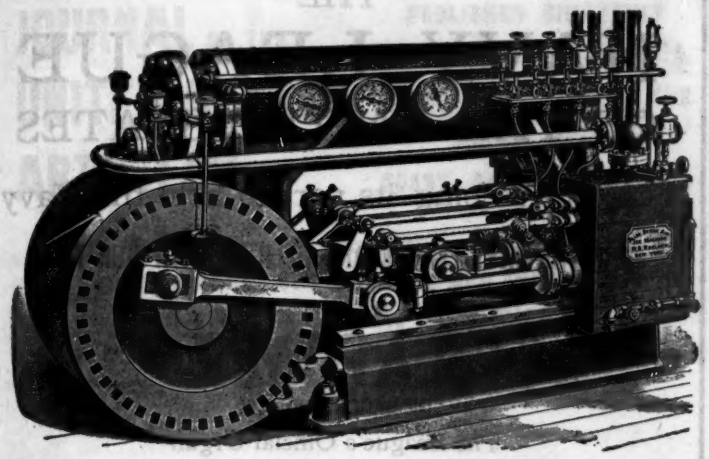

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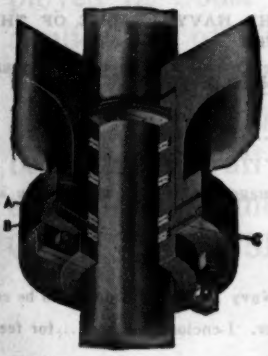

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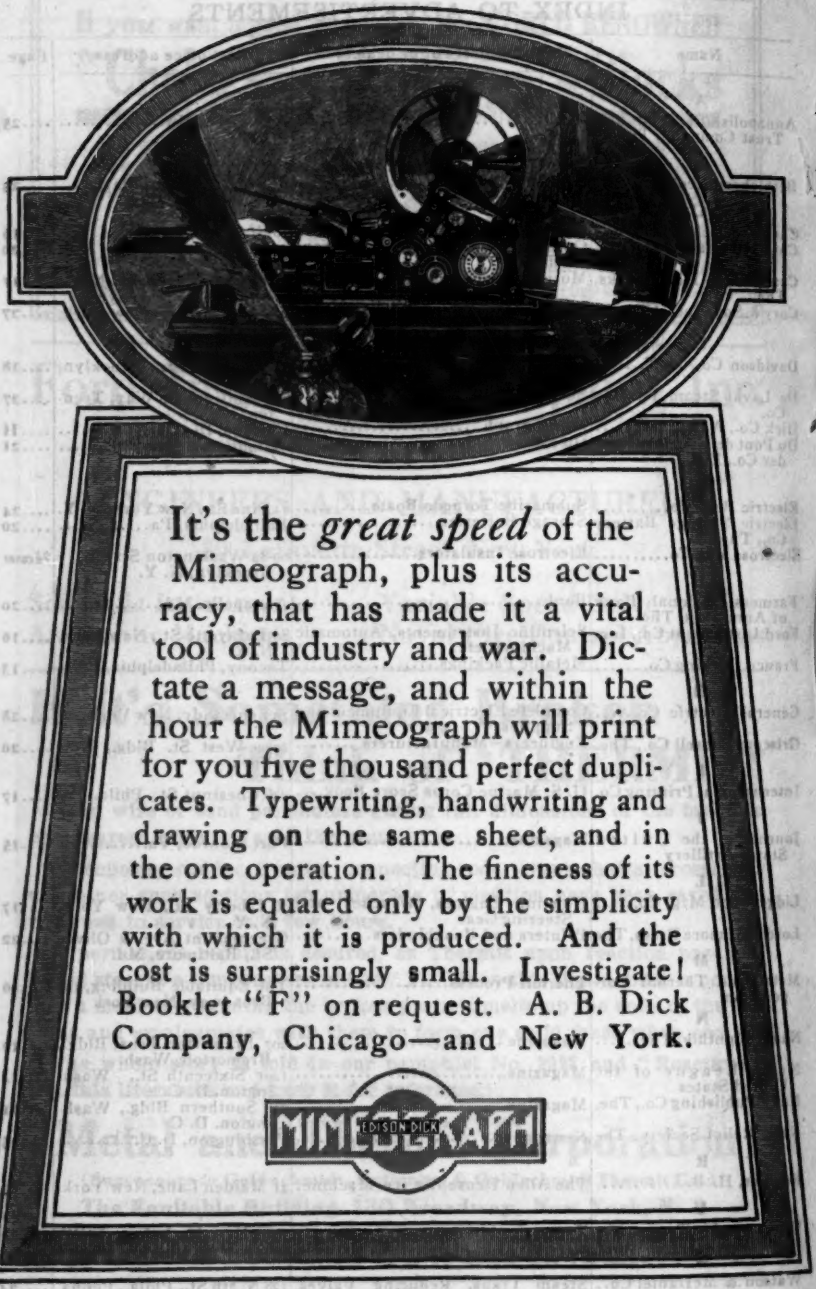
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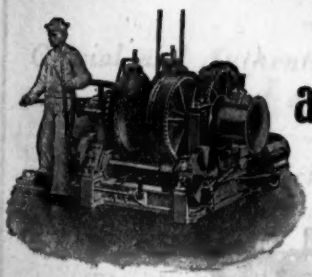

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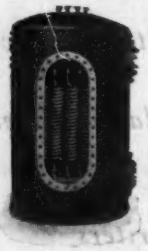

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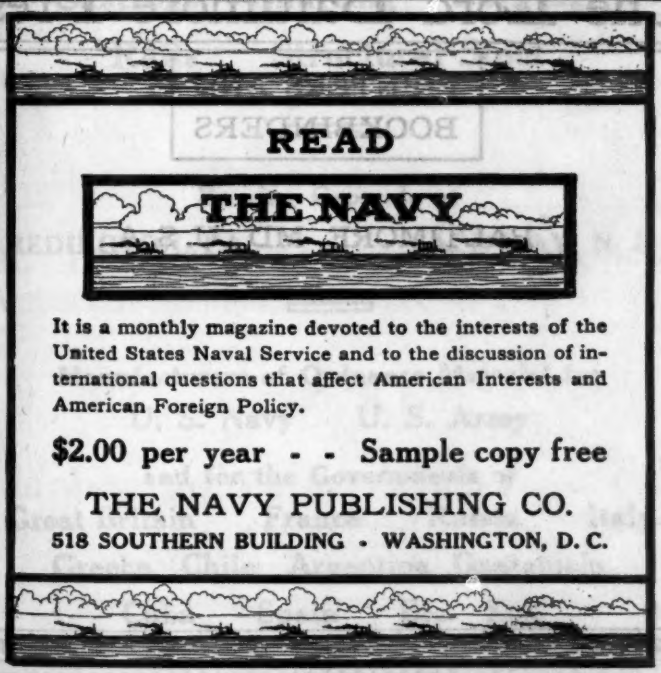
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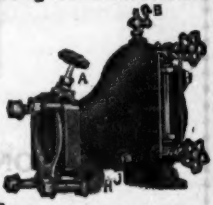


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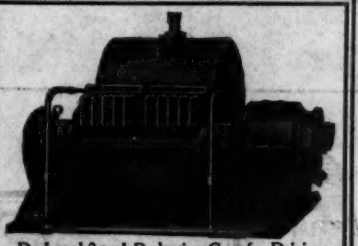

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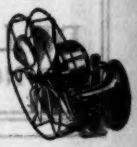

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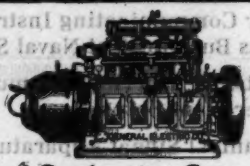

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